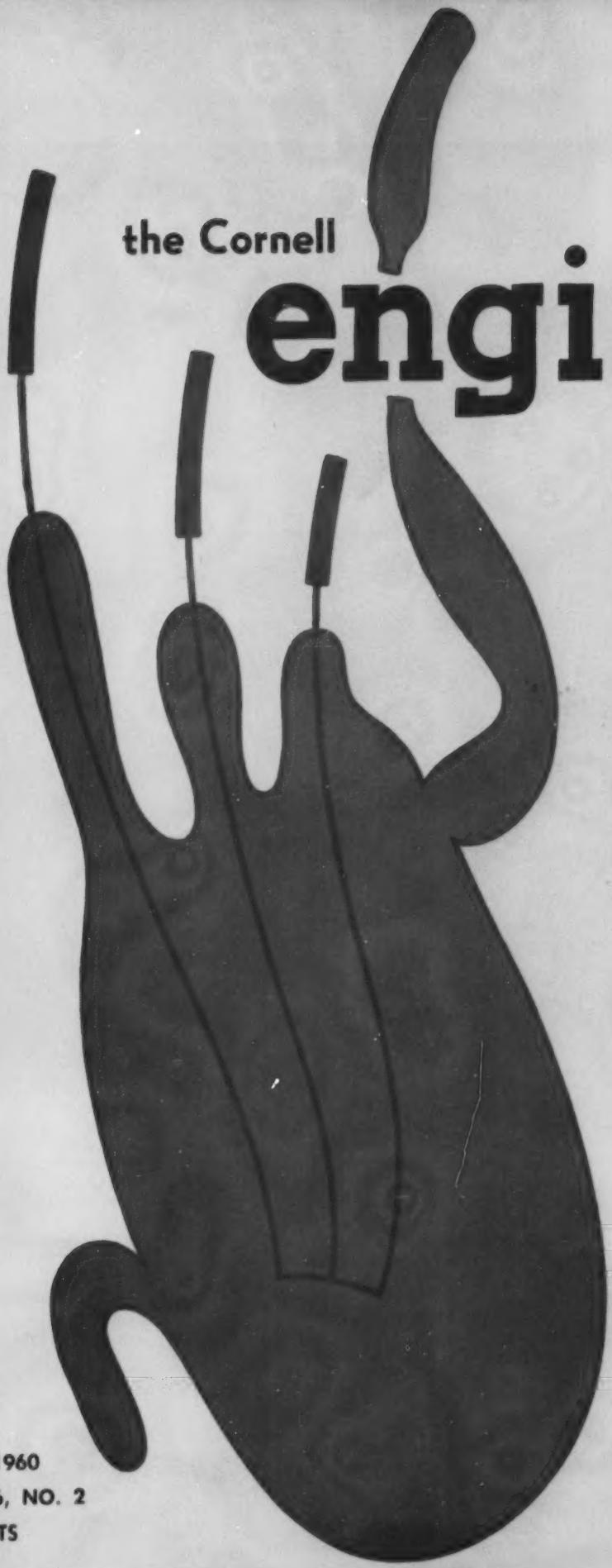
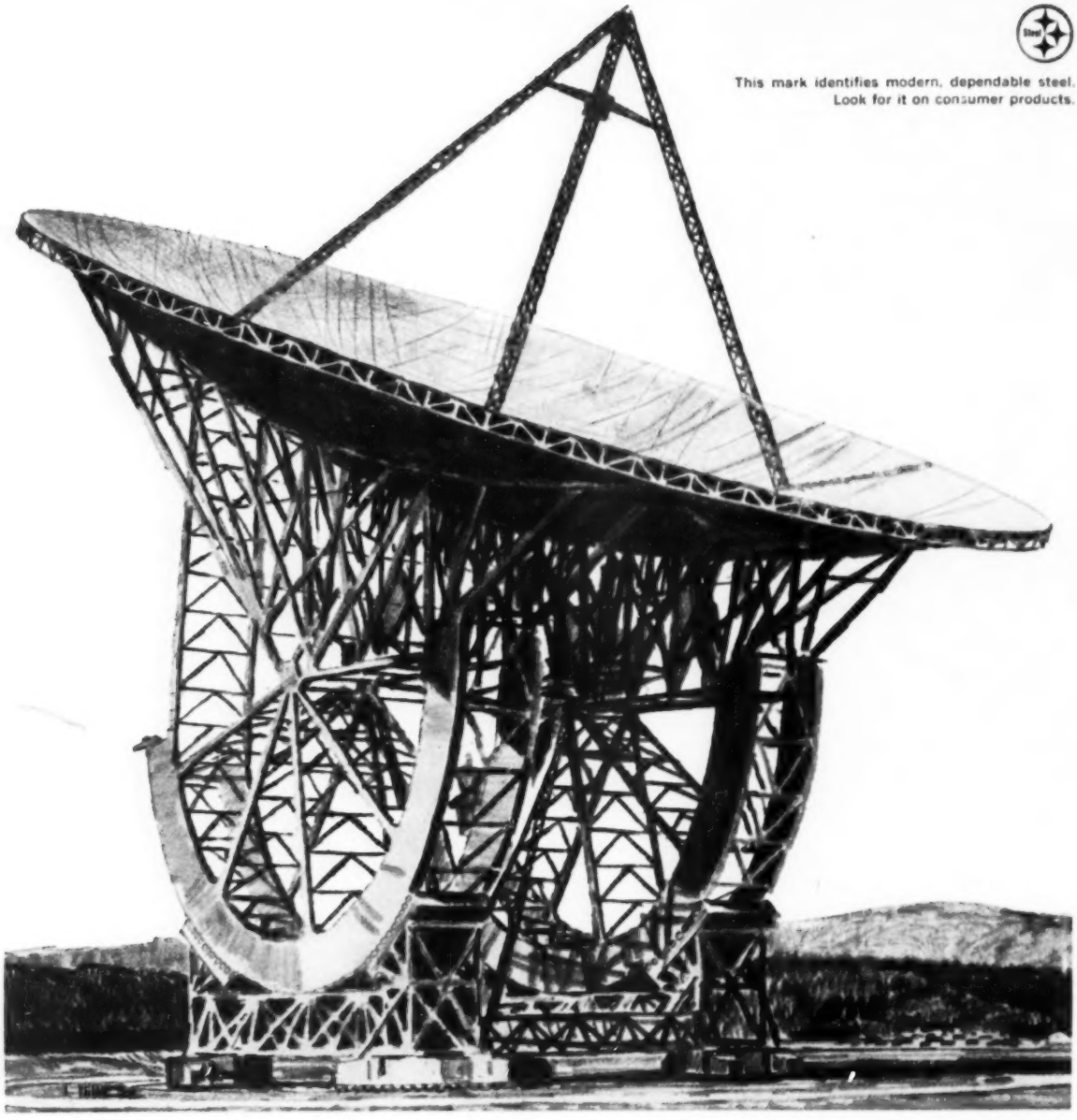
the Cornell engineer



NOV., 1960
VOL. 26, NO. 2
25 CENTS

Ti

This mark identifies modern, dependable steel.
Look for it on consumer products.



This is an artist's concept of the world's biggest radio telescope

This giant telescope will use radio waves to locate objects that are billions of light years out in space. The dish-shaped mirror will be 600 feet in diameter—about the size of Yankee Stadium. It will be the biggest movable radio telescope ever known.

As you'd imagine, it is going to take a lot of material to build an instrument this size. The American Bridge Division of United States Steel, as a major subcontractor, is fabricating and erecting 20,000 tons of structural steel for the framework alone. The U. S. Navy through the prime contractor is supervising the entire job. When it's completed, there'll be a power plant, office buildings and personnel facilities for a permanent 500-man crew. The site is near Sugar Grove, West Virginia.

United States Steel produces many of the materials that are essential for construction: Structural carbon steel; high strength steels; alloy steels; stainless steels; steel piling; steel drainage products; cements; slag; reinforcing bars; welded wire fabric; wire rope; steel fence; electrical cable; and other allied products.

The most important building projects in our nation depend on steel. And *steel* depends on men like you. If you would like to find out about the many career opportunities at U. S. Steel, send the coupon.

USS is a registered trademark

United States Steel Corporation
Personnel Division, Room 6085B
525 William Penn Place
Pittsburgh 30, Pennsylvania

Please send me career information about U.S. Steel.

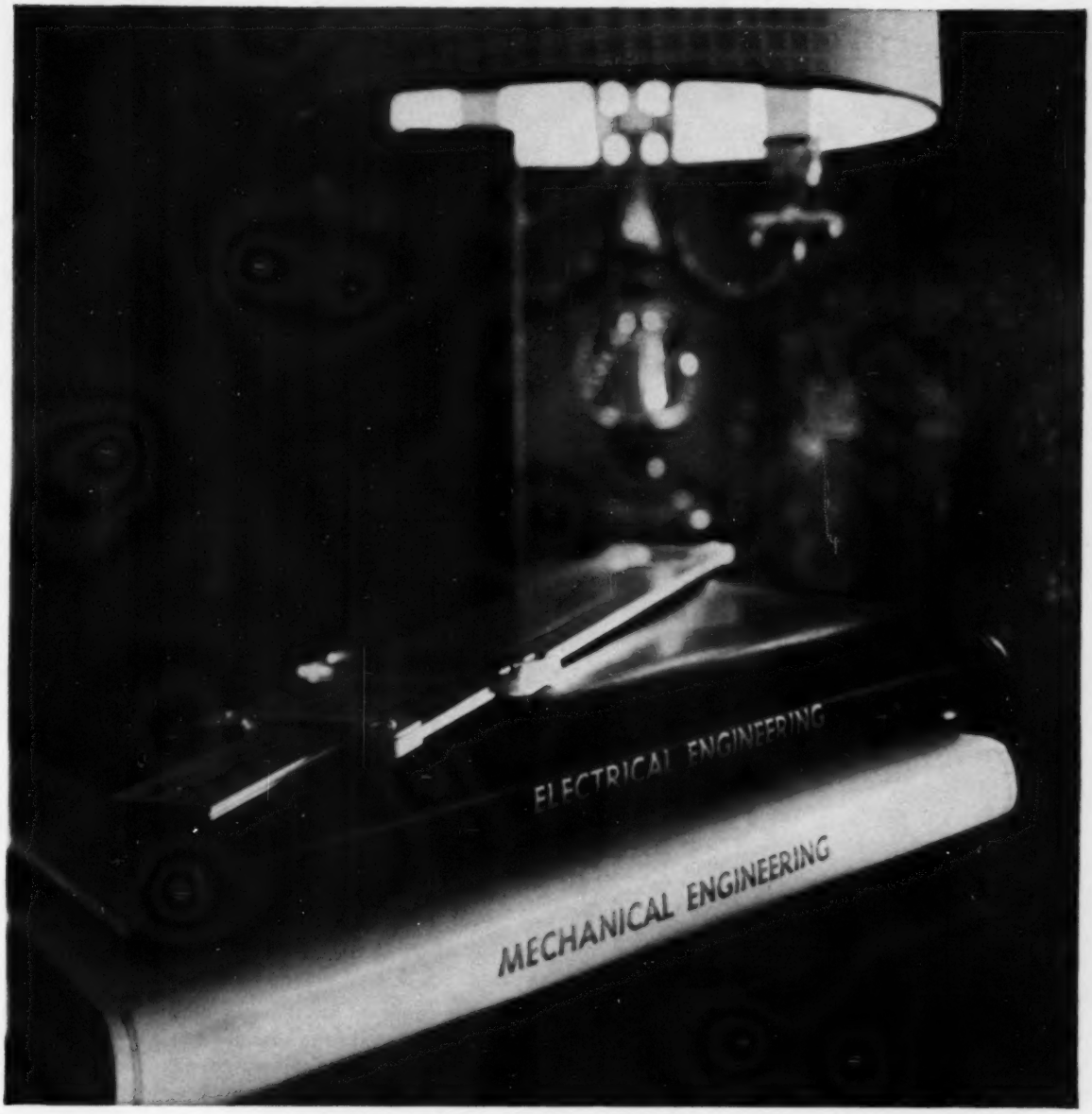
Name_____

School_____

Address_____

City_____ Zone____ State_____

USS **United States Steel**



As you plan your career—be sure to consider Monsanto.

It may surprise you that Monsanto needs *electrical* and *mechanical* engineers, as well as *chemical* engineers.

Fact is, though, that Monsanto offers many opportunities to men with your professional training, including:

Mechanical Engineers . . .

- Plant design and layout
- Equipment selection
- Materials specification
- Design of new and unique equipment
- Plant engineering
- Construction
- Specialization in the fields of fluid mechanics, stress analysis, heat transfer, etc.

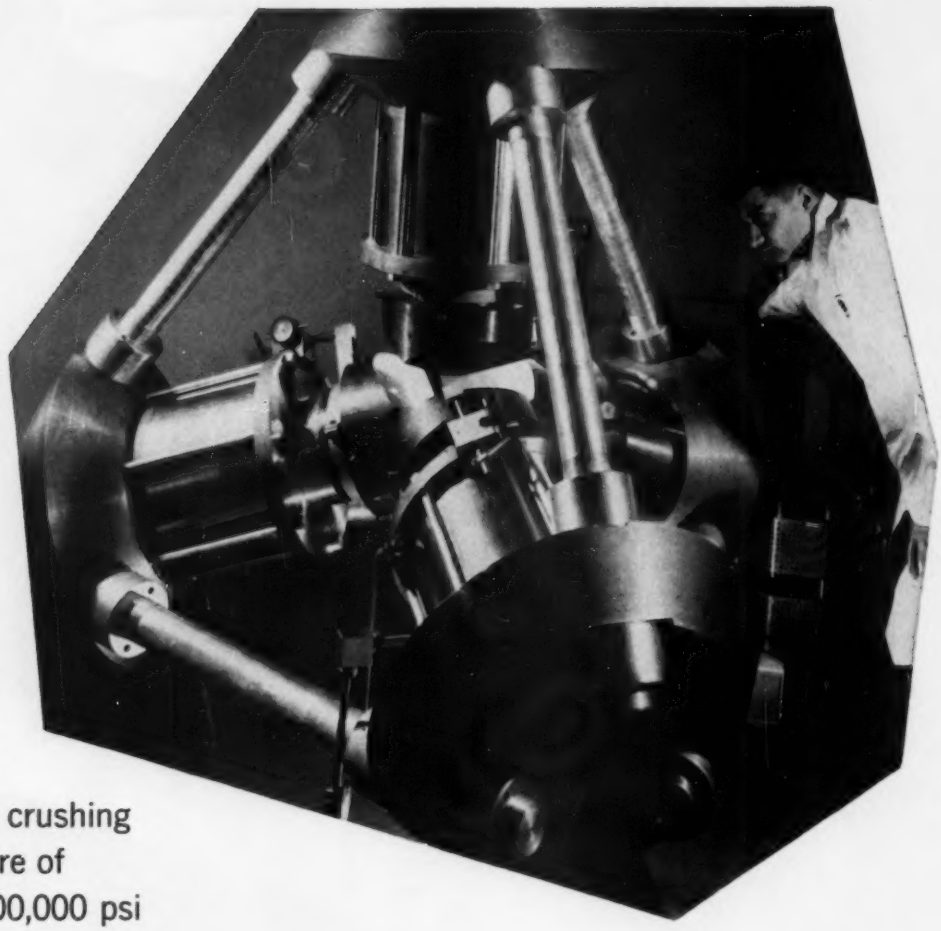
Electrical Engineers . . .

- Design of electrical systems
- Power distribution and substation design
- Process control instrumentation
- Applied research
- Automated process systems engineering
- Equipment evaluation and selection

May we discuss these with you as we visit your campus this year? You can arrange for this visit with your Placement Director; or write Professional Employment Manager, EM-2, Monsanto Chemical Company, St. Louis 66, Missouri.

Monsanto

When writing to advertisers please mention the CORNELL ENGINEER.



The crushing pressure of 2,000,000 psi

At the General Motors Research Laboratories the 600-ton tetrahedral anvil press duplicates pressures which exist 200 miles beneath the earth's surface. The purpose: to study the combined effect of ultra-high pressure and temperature on the physical and chemical properties of known materials with an eye toward improving their properties or even creating new materials.

What happens to solids at pressures of 2,000,000 psi and 7,000 degrees F.? General Motors has the research facilities required to answer these questions. In addition, GM offers experience and diversification to provide the young scientist and engineer with unlimited opportunity.

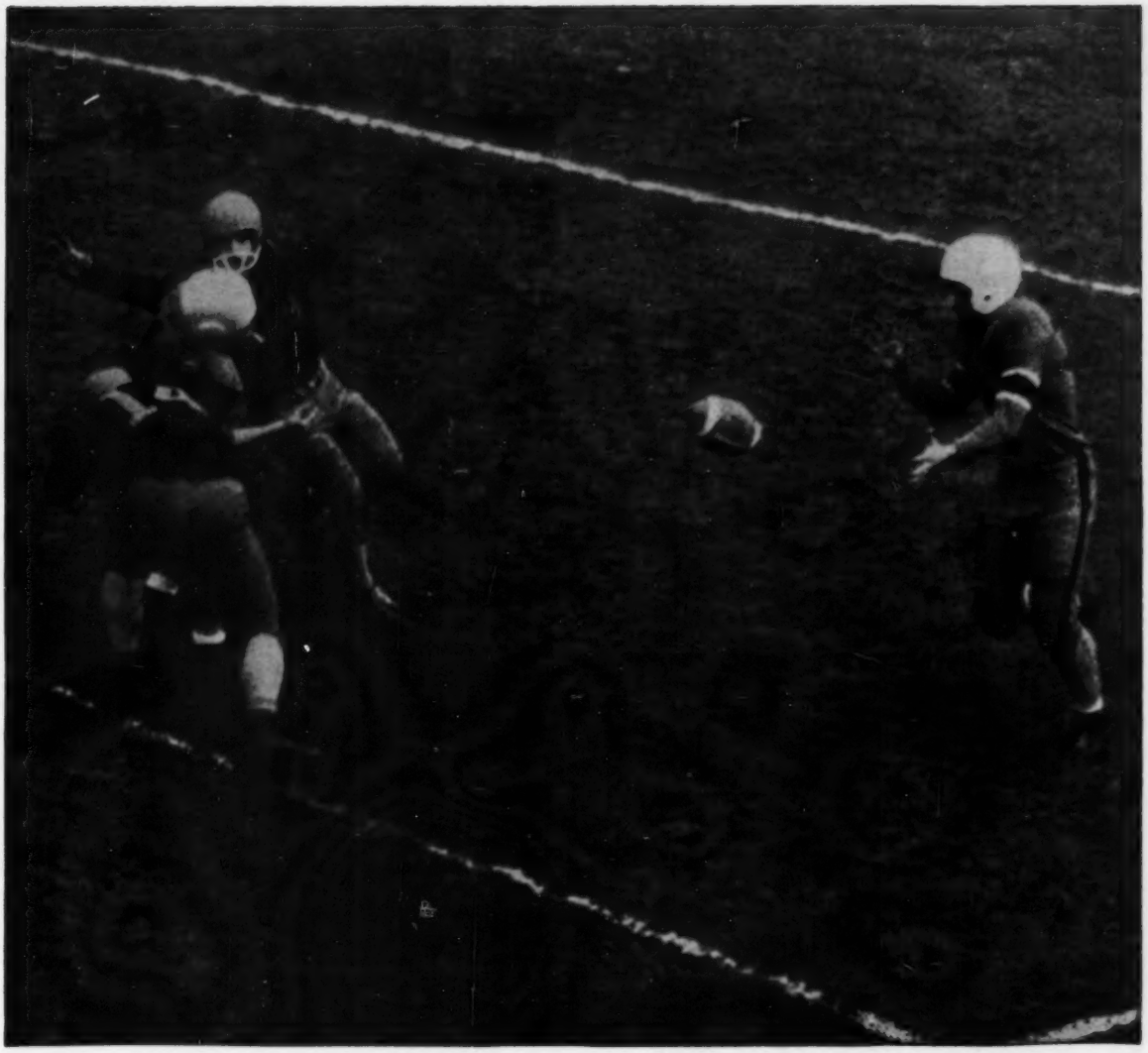
Automotive research, production engineering and manufacturing, electronics and astronautics are just a few of the many technical areas offered. You will be given every opportunity to concentrate on one, or if your interests are varied you may move into other divisions. You'll be in a position to tackle big jobs at GM because this is where important things are being done. It's the opportunity of a lifetime and it offers a lifetime of opportunity.

General Motors also has a program which provides financial aid for postgraduate and undergraduate studies. For more complete information check with your college Placement Officer, or write to General Motors Salaried Personnel Staff, Detroit 2, Michigan.

GENERAL MOTORS

GM positions now available in these fields for men holding Bachelor's, Master's and Doctor's degrees: Mechanical, Electrical, Industrial, Metallurgical, Chemical, and Ceramic Engineering • Mathematics • Industrial Design • Physics • Chemistry • Engineering Mechanics • Business Administration and Related Fields

When writing to advertisers please mention the CORNELL ENGINEER.



How to advance through lateral movement

THE LATERAL PASS is a perfect example of how to get ahead by first going sideways. And lateral movement is a philosophy we use at Koppers.

Here's how it works. Let's say you're a new employee at Koppers. We give you a specific assignment. You find it exciting, challenging. You do a good job. But do we leave you there? Not at all. Once you understand that particular operation, we try you on a different assignment. Here, again, you'll find the work new and stimulating.

You'll never be buried at Koppers. You'll never stand still intellectually. Moving from one operation to another, you'll move ahead. Your assignment won't be to learn just a job, but many jobs. Your compensation? Advancement, responsibility, success.

Your youth won't be held against you. Neither will short tenure. If you have the ability and the desire to get ahead, you'll move fast! Our system of continuous appraisal and evaluation is your guarantee of that.

Koppers is so widely diversified that you can almost name your job. Want to work with chemicals, jet-engine sound control, plastics, sintering plants, wood preservatives, road surfacing materials, electrostatic precipitators? Interested in research? Production? Sales? These are only a few of the fascinating opportunities at Koppers.

Why not find out how you can fit into the Koppers picture? Write to the Personnel Manager, Koppers Company, Inc., Room 230, Koppers Bldg., Pittsburgh 19, Pennsylvania. Or, see your College Placement Director and arrange an appointment with a Koppers representative for the next recruiting visit.

KOPPERS KOPPERS®

When writing to advertisers please mention the CORNELL ENGINEER.

Where do you go from here?

We're not looking for a direct answer.

This is just to remind you that a good knowledge of miniaturization is worth having — wherever you go in the world of engineering.

Keeping engineering minds well-informed on the latest progress in — and with — MPB miniature and instrument bearings is one of our main objectives. MPB bearings are made in over 500 types and sizes, with O.D.'s from 5/8" to 1/10". They are used in over 16,000 applications, ranging from dental handpieces to missile systems.

Magnificent Miniatures, a 16mm color and sound film, pictures the manufacture and uses of MPB bearings. The new comprehensive MPB catalog with basic engineering information, describes the complete line and many applications. Both are available to your class or group, without charge, from Miniature Precision Bearings, Inc., 27 Precision Park, Keene, N. H.

MPB

Helps you perform miracles in miniaturization

the Cornell **engineer**

Robert T. Franson	EP '62	Editor-in-Chief
Lawrence Rosenthal	EE '61	Business Manager
Mary Ann Huber	CE '63	Managing Editor

PUBLICATION BOARD

David S. Kessler	ME '62	Assistant Editor
Robert Stern	EE '63	Associate Editor
Howard Marantz	EE '62	Treasurer
Theodore Spar	CE '62	Circulation Manager
Burton D. Davis	ChemE '63	Advertising Manager
Stephen L. Garrell	ChemE '63	Illustrations Editor
Donald J. Martin	ME '62	Publicity Manager
Deanna Palmer	Ag '61	Office Manager

Editorial Board

J. Shapiro	ME '61	T. Jones	Arch '63
J. Biehler	Arts '62	A. Speare	EP '63
R. Epstein	EE '62	J. Walrath	ChemE '63
R. Karnes	CE '62	D. Henderson	EP '64
G. Rappe	ChemE '62	J. Hughes	EP '64
N. Atwood, Jr.	Arts '63	R. Kaplan	EE '64
H. Green III	ChemE '63	J. Lichtenstein	EE '64
G. Mills	Arts '63		

Business Board

J. Carroll	ChemE '62
L. Goettler	ChemE '62
M. Meyer	CE '62
K. Brown	ChemE '63
D. Harrald	CE '63
D. Nevin	ME '63
T. Hallinan	EE '64
P. Palmer	ChemE '64
R. Solomon	EE '64

Illustrations Board

L. Ioannou	CE '63
G. Klock	EE '63
D. Corkey	EP '64
J. Kreiner	ME '64

Advisory Board

Dean Dale R. Corson

Faculty–Technical Adviser

Prof. R. G. Thorpe
Prof. S. Linke

Alumni

H. H. Williams, Jr.	C.E. '26
I. B. Margiloff	B.Ch.E. '53
R. G. Brandenburg	B.M.E. '58

School Directors

Prof. N. A. Christensen	CE
Prof. H. G. Booker	EE
Prof. C. C. Winding	ChemE
Prof. T. R. Cuykendall	EP
Prof. H. J. Loberg	ME
Prof. O. C. French	AgrE

Member of the Engineering College Magazines Associated

Chairman: Charles E. Wales, Wayne State University, Detroit, Michigan

Publisher's Representatives: Littell-Murray-Barnhill, Inc., 369 Lexington Ave., New York and 737 N. Michigan Ave., Chicago

Founded in 1885

THE CORNELL engineer

NOVEMBER 1960 VOLUME 26 No. 2

From Marshland to Metropolis 15
by Mary Ann Huber, CE '63

The Problem of Admissions 19
by Donald H. Moyer

Titanium—Titan of the Metals 23
by William Smallwood, ME '61

***Research at Cornell:* Machine Shop Simulation** 31

***Faculty Profile:* Professor Roger L. Geer** 34

Molybdenum 36
by Richard F. Allen, ME '62

President's Message 44

Alumni Engineers 45

College News 48

Technibriefs 54

Fifty Years Ago in the Engineer 58

The Cornell Engineering Student Council 61

Stress and Strain 62

COVER is a drawing by Leonidas Ioannou, CE '63, of the original apparatus used to prepare titanium. See page 23 for story.

Published monthly—October to May—by the CORNELL ENGINEER, Inc., Carpenter Hall, Ithaca, N. Y. Edited by the undergraduates of the College of Engineering, Cornell University. Second class postage paid at Ithaca, N.Y., under Section 103, Act of October 3, 1917.

Subscription per year: regular $2.00; with membership in the Cornell Society of Engineers, $3.00; students and faculty, $1.50; single copy, $.25 on campus; $.35 elsewhere.

Copyright 1960 by the CORNELL ENGINEER, INC.

preferably...
a big FISH in the right-sized STREAM

O

We've been told frequently that engineering graduates are attracted to a company our size because of an honest and understandable desire to be "a big fish in a little pond". Perhaps others prefer to think of the future as the challenge of "swimming up-stream".

We believe that Sikorsky Aircraft is actually the "right-sized stream" for young engineers who would enjoy diversified, small-group activities, as well as stature opportunities in a field that is not limited nor professionally confining. Sikorsky Aircraft is the company which *pioneered* the modern helicopter; and our field today is recognized as one of the broadest and most challenging in the entire aircraft industry.

Because of this, we can offer stimulating experiences in an ideal environment. Work associations could include joining an *electronic* team of twenty to thirty associates—or—working with a highly selective group of four or five on interesting problems of *radiation, instrumentation, auto pilotage, automatic stabilization*, etc.

And what of your future?

That, of course, involves your own potential for growth. As a far-sighted company, we're more than willing to help you meet the challenge of "going up-stream"!

For factual and detailed information about careers with us, please write to Mr. Richard L. Auten, Personnel Department.

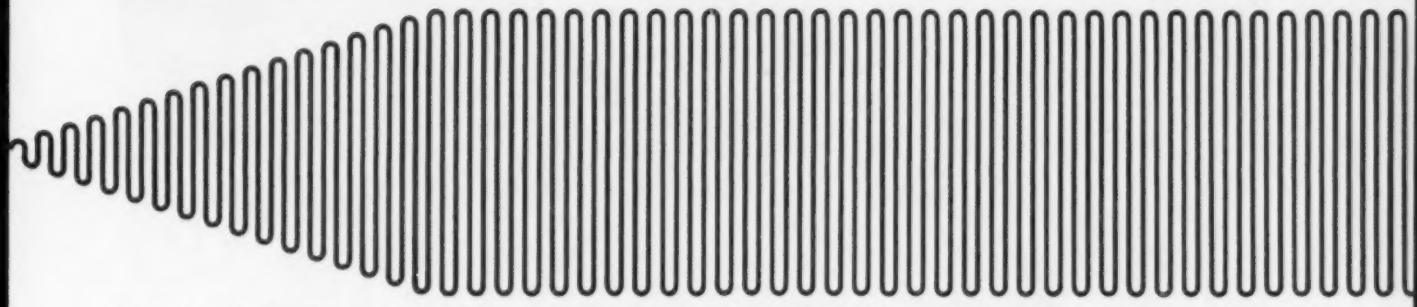
SIKORSKY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

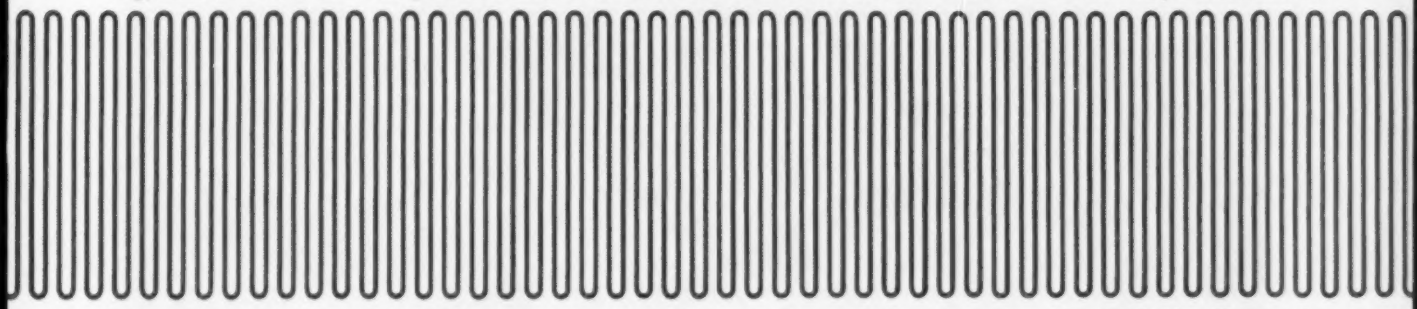
STRATFORD, CONNECTICUT

When writing to advertisers please mention the CORNELL ENGINEER.

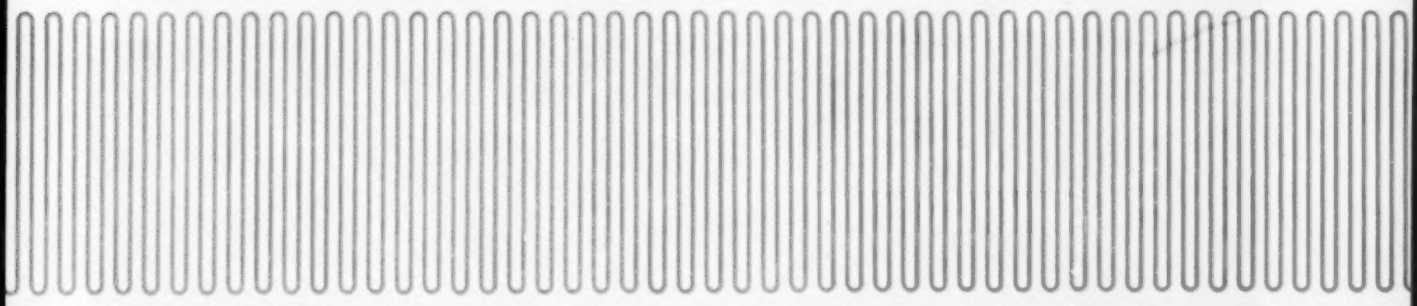
Things we know about tomorrow: Sound waves like these will wash dishes, disperse



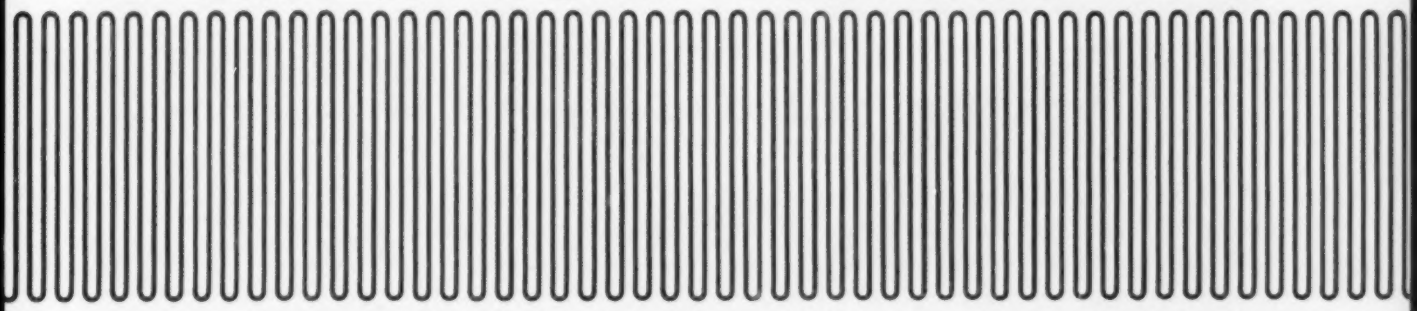
fog, make chemical reactions go faster. Ultrasonic waves can weld one metal to another without heat. Help decontaminate



radioactive parts. Make solder adhere to almost anything, even glass. Perform surgery without a knife. Change the

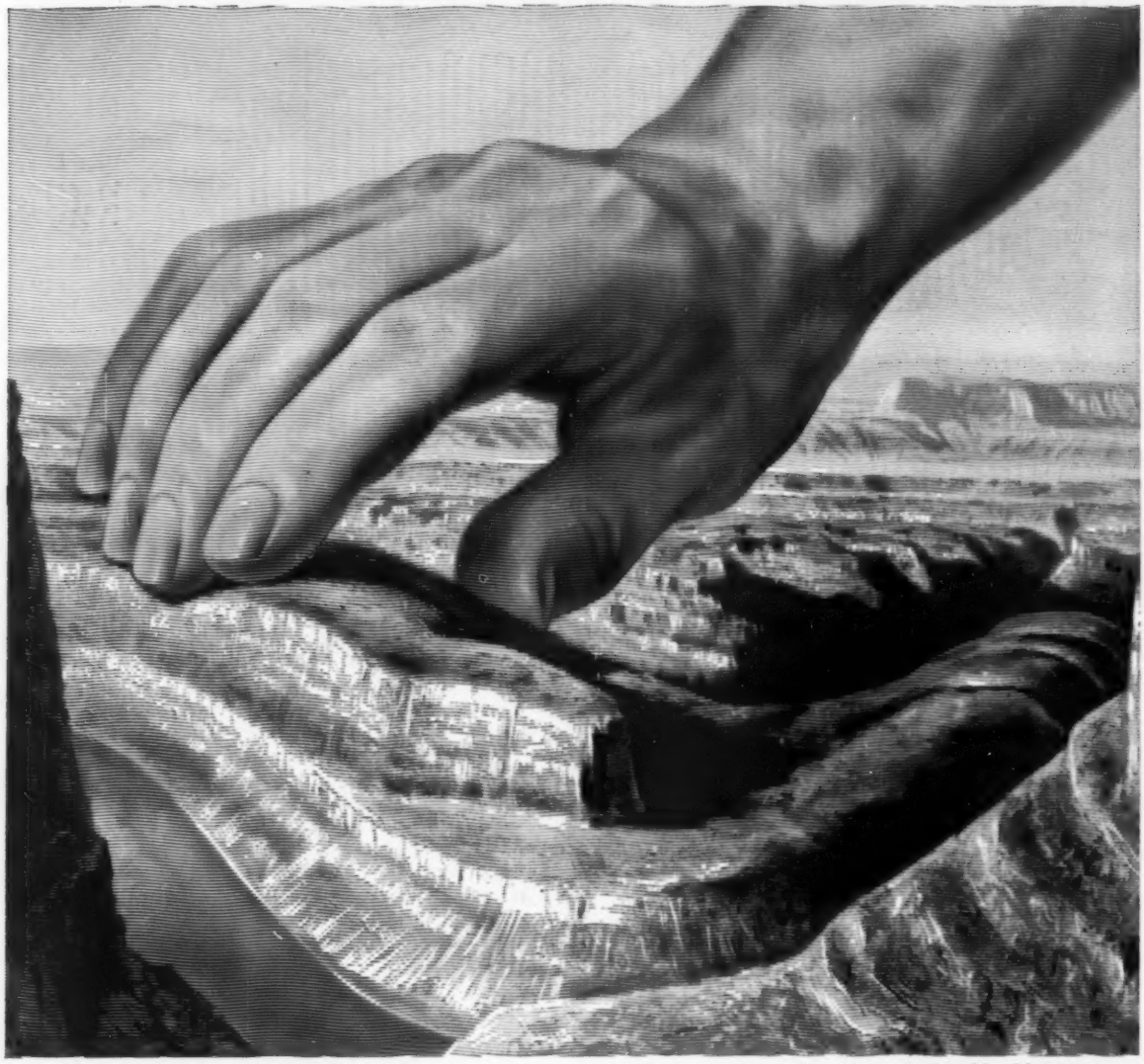


flavors of foods, and the crystals in a steel ingot. Ultrasonics is a major research and development area at Westinghouse



. . . and another reason why Westinghouse is the best place for talented engineers. For more information write L. H.

Noggle, Westinghouse Educational Department, Pittsburgh 21, Pa. You can be sure if it's **Westinghouse**



. . . a hand in things to come

Taking the pulse of a petrified river

From the Colorado plateau—once the floor of a vast inland sea—comes the wonder metal uranium. Using sensitive instruments, Union Carbide geologists find its faint gamma rays along the beds of ancient petrified rivers.

Every ton that is mined ultimately yields just about half an ounce of uranium 235 . . . precious food for atomic reactors. At Oak Ridge, Tennessee—the great atomic energy center operated by Union Carbide for the U. S. Atomic Energy Commission—the fuel becomes the kind of energy that will drive a submarine . . . light a city . . . or help doctors pinpoint the location of diseased tissue.

Finding, refining, and researching the materials used in atomic energy are all part of the work done by the people of Union Carbide to enrich your daily life. With pioneering curiosity, they are seeking new things not only in atomic energy, but also in the fields of carbons, chemicals, gases, metals, and plastics.

Learn about the exciting work now going on in atomic energy. Send for the illustrated booklet, "The Atom in Our Hands," Union Carbide Corporation, 270 Park Avenue, New York 17, N.Y. In Canada, Union Carbide Canada Limited, Toronto.

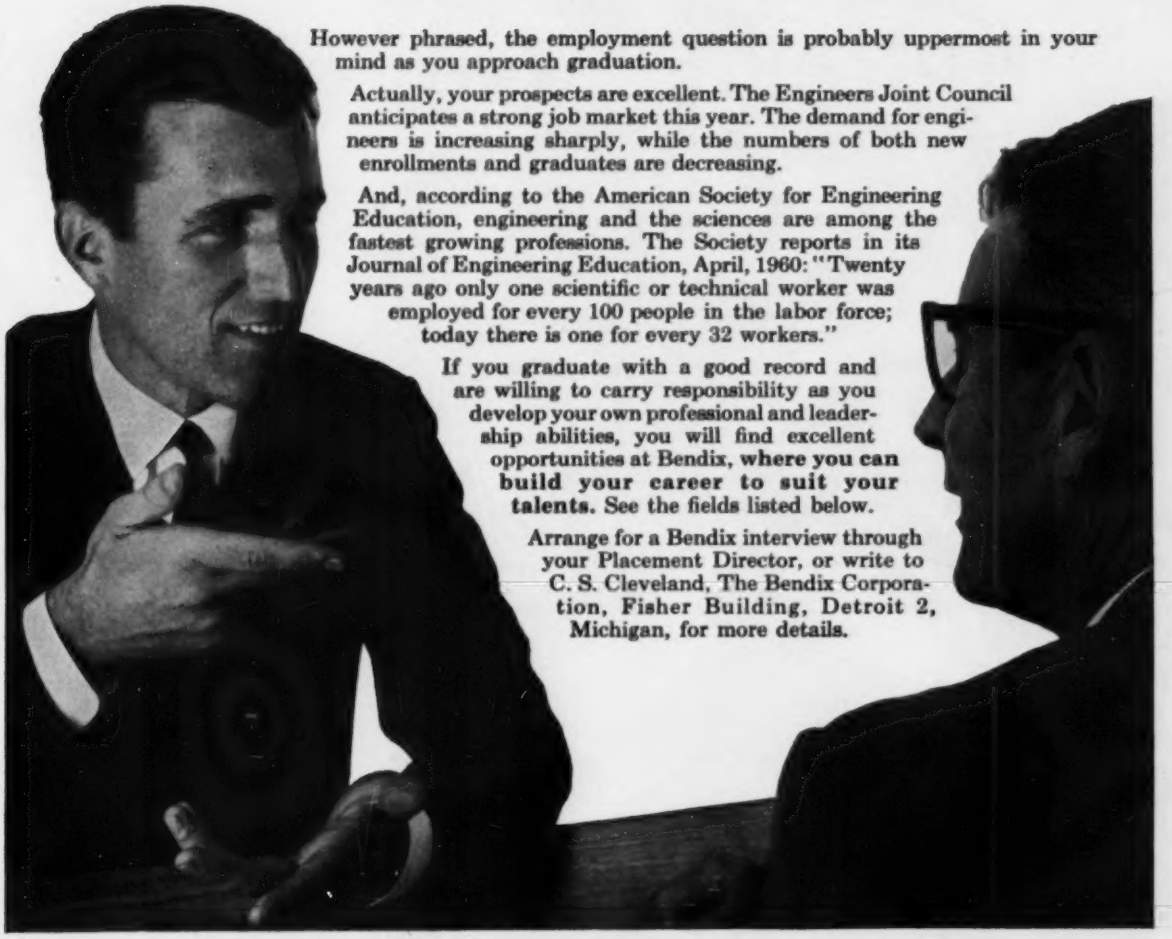
UNION CARBIDE

...a hand in things to come

ONE IN A SERIES

Bendix answers your questions

WHAT ARE MY JOB PROSPECTS?



However phrased, the employment question is probably uppermost in your mind as you approach graduation.

Actually, your prospects are excellent. The Engineers Joint Council anticipates a strong job market this year. The demand for engineers is increasing sharply, while the numbers of both new enrollments and graduates are decreasing.

And, according to the American Society for Engineering Education, engineering and the sciences are among the fastest growing professions. The Society reports in its Journal of Engineering Education, April, 1960: "Twenty years ago only one scientific or technical worker was employed for every 100 people in the labor force; today there is one for every 32 workers."

If you graduate with a good record and are willing to carry responsibility as you develop your own professional and leadership abilities, you will find excellent opportunities at Bendix, **where you can build your career to suit your talents.** See the fields listed below.

Arrange for a Bendix interview through your Placement Director, or write to C. S. Cleveland, The Bendix Corporation, Fisher Building, Detroit 2, Michigan, for more details.

CAREER OPPORTUNITIES IN: CALIFORNIA • CONNECTICUT • INDIANA • IOWA • MARYLAND • MICHIGAN • MISSOURI • NEW JERSEY • NEW YORK • OHIO • PENNSYLVANIA

THE Bendix CORPORATION

A THOUSAND DIVERSIFIED PRODUCTS SERVING THESE FIELDS:

automotive • electronics • missiles & space • aviation • nucleonics • computer • machine tools • sonar • marine

When writing to advertisers please mention the CORNELL ENGINEER.

Thomas O'Connell (B.S. in M.E., Notre Dame, '54; M.B.A., New York University, '60). Recently, as part of his job in marketing at IBM, he found himself assisting the customer technicians with the design problems of one of the world's busiest bridges.

WHAT'S AN IBM MAN GOT TO DO WITH REDESIGNING A BRIDGE?

Tom O'Connell is an engineer working in marketing areas as an IBM Data Processing Representative. His job is to introduce management to the advantages of electronic data processing. Once they have acquired an IBM system, he acts as a consultant on new uses for the system.

A Spectacular Engineering Achievement. How is he helping to redesign a bridge? One of his clients is the agency which constructs and operates transportation facilities in the New York-New Jersey area. Recently, they began to add a lower deck to the George Washington Bridge. It has been a spectacular engineering achievement. Sections were brought up the Hudson River on barges and hoisted hundreds of feet into position. All this while heavy traffic continued in both directions.

This double-decking of one of the world's busiest bridges took complex planning. An IBM system materially aided in the verification of bridge design calculations and in suspension bridge truss analysis under various loading conditions. Tom O'Connell supplied many of the computer programs that were used in conjunction with other programs developed by the customer. Tom now knows a lot more about the problems of bridge design.

A Job That Makes News. One of the exciting aspects of Data Processing Marketing at IBM is this wide diversity of systems application. Using the knowledge a man has gained in college, and backed by the comprehensive training he receives at IBM, he moves into many kinds of application areas. The areas are always interesting, sometimes newsworthy. In fact, almost every day newspapers carry stories about new applications of computer systems in important areas of business, industry, science and government.

If you would like to find out in more detail about the many kinds of marketing opportunities at IBM, our representative will be visiting your campus soon. He'll be glad to sit down with you and discuss the reasons why marketing is a career with a virtually unlimited future. Your placement office can make an appointment. Or you may write, outlining briefly your background, to:

Charles B. Finley
IBM Corporation
425 Park Avenue
New York 22, New York

IBM®

You naturally have a better chance to grow with a growth company.

The care and feeding of a missile system

It takes more than pressing a button to send a giant rocket on its way. Actually, almost as many man-hours go into the design and construction of the support equipment as into the missile itself. A leading factor in the reliability of Douglas missile systems is the company's practice of including all the necessary ground handling units, plus detailed procedures for system utilization and crew training. This complete job allows Douglas missiles like THOR, Nike HERCULES, Nike AJAX and others to move quickly from test to operational status and perform with outstanding dependability. Douglas is seeking qualified engineers and scientists for the design of missiles, space systems and their supporting equipment. Write to C. C. LaVene, Box B-600, Douglas Aircraft Company, Santa Monica, California.

Alfred J. Carah, Chief Design Engineer, discusses the ground installation requirements for a series of THOR-boosted space probes with Donald W. Douglas, Jr., President of DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB® ■ GROUND SUPPORT EQUIPMENT

When writing to advertisers please mention the CORNELL ENGINEER.

Performance Centers on SEALMASTER QUALITY!

QUALITY . . . The assurance that the second or two hundred and second SEALMASTER Ball Bearing Unit you buy will be as precision-perfect as the first. A combination of exclusive engineering features and scientifically-controlled production have made the name SEALMASTER synonymous with quality throughout industry.

PERFORMANCE . . . more hours of efficient power transmission and precision service from every SEALMASTER Ball Bearing Unit.

ECONOMY . . . more for your bearing purchasing dollar. SEALMASTER quality and performance continues to pay dividends long after the original purchase.

AVAILABLE IN A COMPLETE QUALITY ENGINEERED LINE

SEALMASTER
BALL BEARING UNITS

Normal-Standard Medium Duty PILLOW BLOCKS

Standard Medium Duty FLANGE UNITS

FLANGE CARTRIDGE UNIT

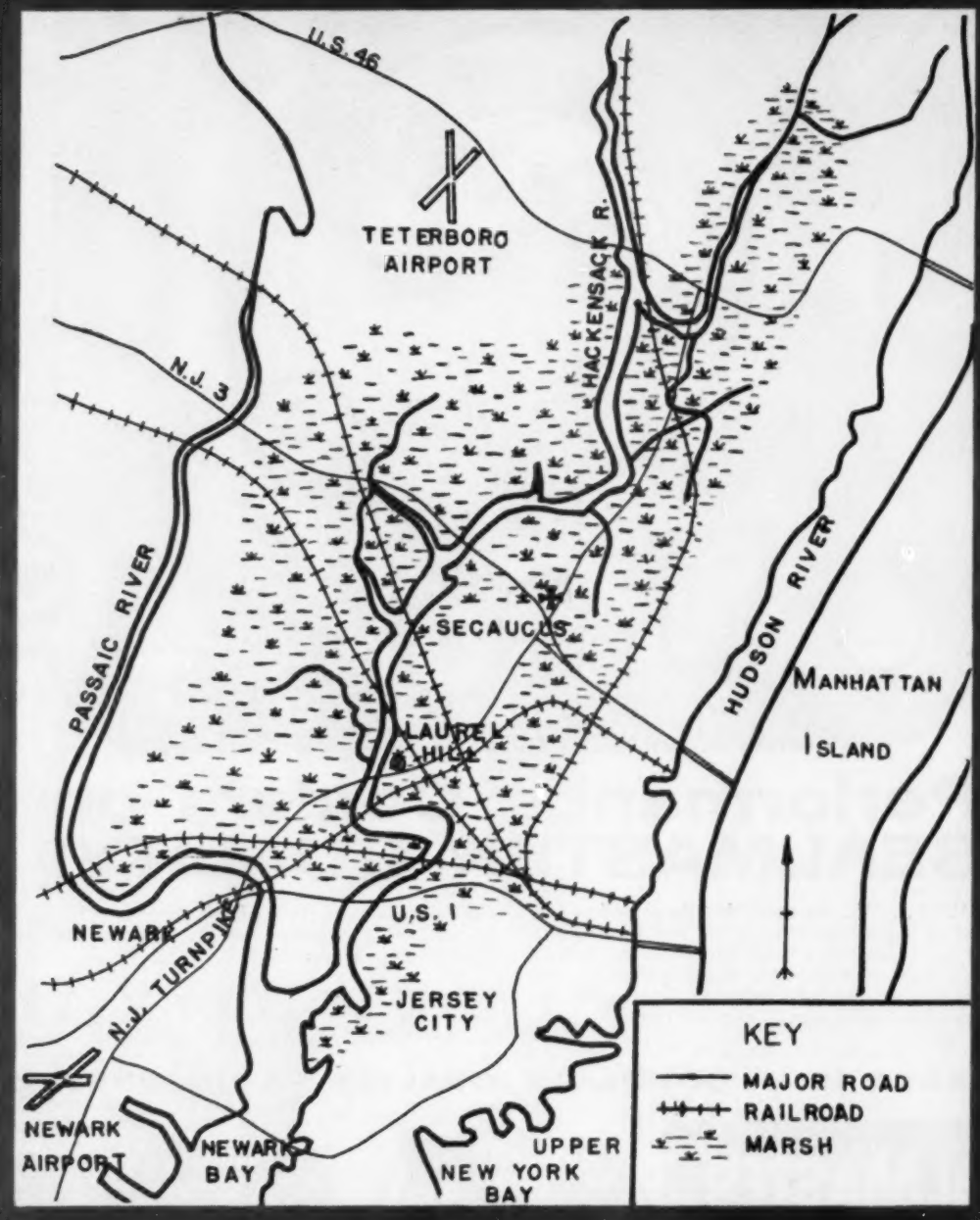
LP PILLOW BLOCK

LF FLANGE UNIT

SEALMASTER BEARINGS A Division of STEPHENS-ADAMSON MFG. CO., 93 Ridgeway Avenue, Aurora, Illinois

PLANTS IN: CLARKSDALE, MISSISSIPPI • LOS ANGELES, CALIFORNIA • BELLEVILLE, ONTARIO • MEXICO CITY, D. F.

When writing to advertisers please mention the CORNELL ENGINEER.


U.S. 46
TETERBORO AIRPORT
HACKENSACK R.
N.J. 3
PASSAIC RIVER
SECAUCUS
HUDSON RIVER
MANHATTAN ISLAND
LAUREL HILL
U.S. 1
NEWARK
N.J. TURNPIKE
JERSEY CITY
NEWARK AIRPORT
NEWARK BAY
UPPER NEW YORK BAY
KEY
MAJOR ROAD
RAILROAD
MARSH

FROM MARSHLAND TO METROPOLIS

by Mary Ann Huber, CE '63

Within sight of the towers of New York City lies a vast wilderness of potentially great value to the metropolitan vicinity. This bleak wasteland, the marsh of the Hackensack River basin in northeastern New Jersey, offers more than forty square miles of untouched territory for industrial development. Factories and research centers located here could reap tremendous benefits from proximity to New York City, Newark, and Philadelphia, and from the easy access to transportation afforded by the railroads and super-highways threading across the area. The obstacles to the use of these marshlands, however, are great, for they provide a weak and poorly drained base for buildings, and in their present state require considerable improvement to make them suitable for foundations.

Regional History

The conditions which caused this situation reach back to the time of the Pleistocene glaciation, about fifteen thousand years ago. During that last ice age, enormous glaciers had pushed southward over North America, nudging ahead of them huge amounts of dirt, rock, and other debris. Finally their march was halted, when they had pushed so far south that their rate of forward motion was offset by their rate of melting. At this southernmost point of their advance, they deposited their debris load in a moraine, and began their slow retreat northward. However, the moraine, extending through Perth Amboy, New Jersey, across Arthur Kill to Staten Island and Long Island, acted as a huge dam, trapped the glacial melt waters behind it in lakes, one of which was Lake Hackensack. The valley holding the lake was bounded on the west by shale and sandstone hills and a ridge of basalt, and on the east by the mammoth diabase sill of the Palisades. Also to the east were Lake Hudson and Lake Flushing, impounded by other portions of the glacial moraine. Lake Hackensack occupied the region for some 2500 or more years, according to studies of clay deposits in the area. These clays were laid down on the lake bottom seasonally in very thin layers called varves, and were composed of sediments carried by streams and the glacial melt waters. A count of these varves reveals the length of the lake's existence. Their presence proves that the lake was fresh water and not merely a bay of the sea, for the ionic substances in sea water cause suspended particles to settle out rather homogeneously.

As the underlying earth was relieved of its heavy ice burden, it adjusted to the decrease in pressure by rising in back of the moraine; in time the lake waters breached the barrier and drained into the sea. During the period of Lake Hackensack's formation and existence, changes occurred in the level of the sea. Since much of the world's water was locked in the glaciers during their period of greatest advance, the surface of the ocean was much lower than at present, probably by about 300 feet, and the coastline may have been as much as eighty miles beyond today's shore. As the glaciers began their retreat, the waters were once again released into the sea, and its level slowly rose, reaching the height of the southern Hackensack valley some time after the lake had drained.

Plant Life

Soon the forests claimed the former lake bed, now a flat plain of sand and clay. The first tree to leave evidence of its presence was the black ash. However, the sea level was still slowly rising and with it the area's water table. These conditions favored the development of a forest of larch and black spruce, which gradually succeeded the black ash. Both these forests left their record in the peat which underlies the region today and provides a sampling of former plant life for the botanist. The sea continued its encroachment upon the land, until these species, too, became incapable of survival, and were slowly replaced by a new forest of white cedar.

Map of the Hackensack River Valley and meadows, showing major highways and railroads, emphasizes the extent of the marshlands and their proximity to New York City.

Mary Ann Huber

Mary Ann Huber

The Hackensack meadows lie within sight of New York City. In this photo, note the towers of Rockefeller Center and the Empire State Building, seen above the ridge of the Palisades.

By the beginning of this century, the last of the larch and spruce trees were gone, and stands of cedar covered large portions of the meadows. New Jersey's early settlers realized the value of the cedar forest, and used the wood of the trees for ship and road building. Although this did not cause extensive damage to the forests, it was a small step of the many that led to the cedar's final annihilation in the area.

With the advent of communities around the margin of the forests, a new danger threatened; this was fire. Although the cutting of the salt grass in the woodland helped furnish fire breaks, destructive blazes ravaged the cedars time and again, growing more frequent when gasoline engines were introduced and the grass was no longer needed for horse bedding. Curiously enough, some of the earliest fires were set intentionally to rout robbers from the forest.

Meanwhile the sea continued its relentless advance. Very saline water reached farther and farther up the creeks draining the area, the salt content finally reaching a level the trees could not tolerate. In New Jersey there still exist cedar bogs similar to those once occuping the Hackensack region, but water from these locations is far less saline than the water in the present marsh. The forest's last survivors stood in small groves on tracts where the ground water was still relatively fresh, but gradually these areas shrank, and with them the domain of the cedar. Adding to the ground water problem, newly founded industrial plants began to dump their wastes into the streams, polluting them.

It remained for man to complete the destruction that fire and brackish water had begun. Principally a marshland, the meadows became a breeding place for the notorious New Jersey mosquitos. In an effort to control the pest, the Civilian Conservation Corps instituted a program of ditching to improve drainage of stagnant areas. This allowed a renewed influx and deeper penetration of sea water, and finally about 1935 the last lonely cedars withered and died.

The Meadows Today

As the cedar vanished, foxtail, cattail and other reedlike plants invaded rapidly and blanketed the area. Today the meadows are a vast sea of these, relieved only by the drainage system and scattered shrubs. Although many formerly abundant species, such as the huckleberry, died out with the cedars, the marsh still contains over one hundred different types of plant life.

Animal life has also been severely affected by increasing water pollution and other factors. Raccoons have completely deserted the meadowlands, and the weasel, duck, and rabbit populations are decreasing. The hardy muskrat, however, remains in large numbers, and provides a full-time source of income for the twenty-odd trappers working the meadows. His diet, consisting of roots, finds more than ample satisfaction in this territory, and his fur grows luxuriantly in the temperate New Jersey climate. The pelts of muskrats trapped here are considered among the best obtainable in the United States.

Today, the meadows provide favorable sites for a variety of enterprises. Their flatness and relative freedom from high obstacles prompted the building of Newark and Teterboro airports to serve the metropolitan area. The level topography also proves a boon to the many railroads which crisscross the marshes on their way to New York City, for several companies have located huge yards there. The sole

punctuation marks on the flat surface are the towers raised by radio stations for transmission over this ideal expanse.

Schemes for Reclamation

Even before the final disappearance of the forests from the Hackensack valley, various schemes were proposed to reclaim the areas already barren. One early such proposal was brought forth in 1874 in a report to the Common Council of Newark on that city's sewage problems. A certain tract of the meadows, located near today's industrial center of Harrison, was deemed a future "healthful habitation of 250,000 inhabitants". The report cautioned against poorly executed attempts at drainage, and warned that such blunders could turn the site into a disease-breeding health hazard for the city.

The report set forth several steps for accomplishing this transformation. In order to prevent any tidal overflow and to provide a sufficient drainage head, the plan called for the dredging of Newark Bay and the use of the material obtained to raise the land surface to about five feet above high tide. The report also pointed to the benefits derived from the dredging itself, since it was expected to open new dock sites and thus attract factories to the shores of Newark Bay.

To insure proper drainage and sanitation for the newly-created district, the proposal suggested that the saturated soil be drained to below the tidal level, and that refuse and storm water be removed as quickly as possible. This efficient drainage would be achieved by dividing the territory into three separate areas, each with its own sewerage system. The plans also included provision for spacious parks, a great diagonal avenue to facilitate traffic motion, street railways, and a ship canal across Bergen Neck to New York Harbor to stimulate water-borne commerce. The report urged an early start on the project, speculating that "it may not be all done in fifty [years]". Although this scheme never materialized, much of the land it sought to reclaim has been filled in and is now a site for heavy industry.

In 1897, State Geologist C. C. Vermuele suggested a sweeping plan for developing the entire meadows area. In place of the residential plan previously proposed, Vermuele envisioned new grazing lands and market gardens, with factories bordering the waterways. He sought to place the entire reclamation project under some sort of central commission responsible for the coordination of the work.

Three major methods were considered for accomplishing the task. The first involved the dredging of canals throughout the meadowlands, and the use of the dredged material to raise the land level. For this purpose, canals about 100 feet wide and twelve feet deep would be constructed. The fill obtained from these would raise a 300 foot wide strip along the canal margin by about three feet. When the work reached completion, three-fourths of the meadows would be dry land, the rest open water. However, the report pointed out that, though this method would improve the waterways considerably, it would be suitable only near the major rivers, would involve high maintenance costs for the canals, and would impede land travel. Moreover, if the water were not properly circulated, the canals might become hazards to sanitation.

A second suggestion called for filling of the marshes with earth and refuse. Although this method might have proved practical on the edges of the large cities, the cost of obtaining and hauling fill to the central reaches of the area would have been prohibitive. Such a procedure would require a great amount of material because of constant settling. The third means considered was that of embanking and pumping, which had been tried successfully in England and Holland. Under this plan, dikes would be constructed by excavating ditches and piling the material to a height of about four feet above the marsh surface. A central core of sheet piling would provide extra strength for the dikes, which would taper from a base width of eighteen feet to six feet at the top. Tidal sluices would provide drainage, and if these later became ineffective because of land settling, pumping would be em-

Mary Ann Huber

Ghostly remains of the cedar forest formerly occupying the Hackensack River Valley stand among the foxtails near Secaucus, New Jersey (see maltese cross on map). They were destroyed by combined effects of fire and salty, polluted water. (Below) Foxtails (Phragmites communis) have invaded the meadowlands and now cover the area.

ployed. Vermuele planned that the reclamation should encompass the entire meadows area, and he presented considerations of the special engineering problems to be encountered in each of twelve separate districts. The Newark sector, he asserted, would be the first to be built upon; he also expressed hopes for a marginal drive along the Passaic River. This last was the only phase of the scheme to bear fruit, for New Jersey is now constructing a modern Route 21 along that river's banks.

Recent Plans

The Depression years saw the proposal of two very practicable schemes for meadows reclamation. The first, suggested in the "Regional Plan of New York and Environs", 1929, called for the use of only 4000 acres for industrial purposes, the remainder for residential development. The second plan, devised by the Meadow Reclamation Commission in 1930, reversed these apportionments for land use. They were, however, in close agreement on reclamation methods. They hoped to achieve their objective by a program of land fill, accompanied by stream channelization and extensive straightening of the winding Hackensack River. Due to the economic situation, neither of these proposals reached the construction stage.

One of the most recent and novel propositions has been suggested by the Passaic Valley Citizens Planning Association. If completed, this project would provide 7000 acres, primarily for industrial use. The nucleus of the scheme is a dike extending along the west bank of the Hackensack River. The embankment supporting an already-existing service road for a transcontinental gas pipeline has been mentioned as an excellent dike facility, since it is built in approximately the right direction. If this should prove unsatisfactory upon further investigation, the Association recommends the construction of a dike along the river, possibly topped with a much-needed highway. Pumps, tide gates, and water storage basins would provide adequate drainage for the newly created lands behind the dike. The foreshore, between the dike and the actual river bank, would be reclaimed by filling, and would provide added fortification for the dike-protected lands. The entire area would be divided into development areas, to be opened for use as demand requires.

Whether the Hackensack Meadows will ever fulfill its enormous potential cannot be predicted at present. However, it seems probable that, as pressures on urban population and industries increase, necessity will supply the spur to development that opportunity alone has not been able to provide.

Acknowledgements

The author wishes to express appreciation to the following people: Mr. Ernest Erber of Passaic Valley Citizens Planning Association for use of Association reports.

Dr. Calvin J. Heusser of the American Geographical Society for information on geological and botanical history of the meadows.

Mr. H. K. Englishman and Mr. C. A. Van Antwerpen of New Jersey State Highway Department for suggesting sources of information on reclamation projects.

Design for your future!

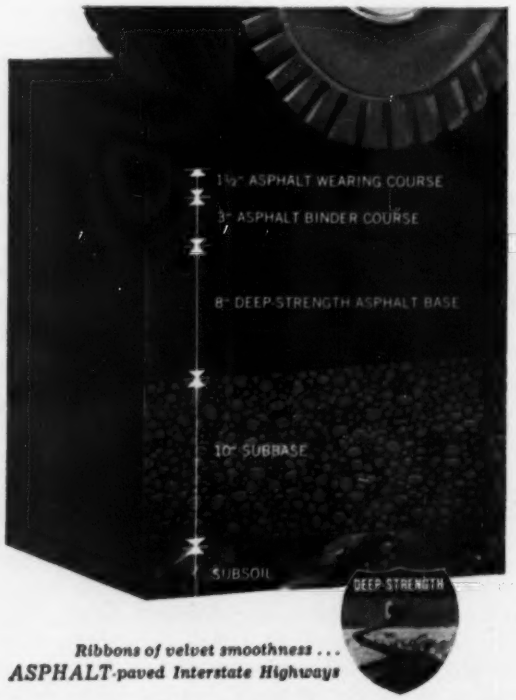
Learn how to build the new DEEP-STRENGTH Asphalt pavements

If you're going into Civil Engineering, it will pay you to keep a close eye on Asphalt design developments.

Here, for example, is the latest from Oklahoma . . . one of the new, DEEP-STRENGTH Asphalt pavements the state is using on Interstate 40. *This* one is outstanding because its base is 8 inches of hot-mixed—hot-laid sand-Asphalt . . . no coarse aggregate.

Why 8 inches? Why not 6 or 10? What did engineers do to insure good drainage? What factors set the design?

The Asphalt Institute answers questions like these . . . keeps you abreast of all the latest in the design of Asphalt Highways, the most durable and economical pavements known. Would you like our new booklet, "Advanced Design Criteria for Asphalt Pavements", or our "Thickness Design Manual"? Write us.



Ribbons of velvet smoothness . . .
ASPHALT-paved Interstate Highways

THE ASPHALT INSTITUTE
Asphalt Institute Building, College Park, Maryland

Donald H. Moyer

THE PROBLEM OF ADMISSIONS

by Donald H. Moyer, Director
Office of Student Personnel
College of Engineering

I am going to talk to you about some of the unique characteristics of engineering education and the even more unique atmosphere of our own engineering college, and the problems of student selection which these conditions impose. For those of you who have a desire for a longer and closer look at admissions problems, I suggest an excellent report on admissions at Yale, which appeared in the Reporter at Large department of the New Yorker in the issue of September 10.

The curriculum and climate of any college or university must necessarily be the principal determinants of admissions policy. In admitting students to the College of Engineering, we have problems of deciding who is bright and who is not, of geographical distribution and financial aid, of effective recruitment of all our students, including legacies, athletes, and foreign students, but our primary task is to pick young people who will thrive in an engineering college, and especially the College of Engineering at Cornell, which differs from M.I.T., Purdue, or Stanford.

Studying engineering is not just "going to college"; it means pursuing a professional curriculum like law or medicine, but at the undergraduate level. The prospective lawyer or medical doctor goes first to a liberal arts college, deferring until four years later his special or professional training. By contrast, the prospective engineer embarks at once, at the age of seventeen or eighteen, on a highly structured course of professional work, implicit in his doing so a deliberate and considered choice of his vocation and the will to pursue the choice to its attainment.

The engineering student will carry a heavy load of courses, most of which are prescribed for him in the first two years; he will have long hours in classroom and laboratory, about five hours of homework a day, and whatever natural brilliance and interest in engineering he may possess or later acquire must sustain him in this academic regimen for four or five years. As a freshman he is expected to have a firm vocational goal and the will to pursue it relentlessly in a curriculum of mostly required courses. We must find students who can do this.

We must also seek students whose interests span seven branches of engineering and a variety of functions ranging from research to sales and running the gamut from egg head theorists to highly practical men of affairs who, as technologists or administrators, must be devoted to a complex of men, materials, and money. How much simpler our problem of selecting engineering students might be if, as Gertrude Stein might have said, "an engineer is an engineer is an engineer!"

Whatever specific objective the student engineer may have, he must be equipped to profitably study two or three years of basic and engineering science of a highly theoretical nature, yet be equally capable of adapting himself to technological courses of a practical sort, and besides this, learn to make speculative and philosophical judgments in courses in the humanities and social sciences which will occupy about 20% of his time. This all too briefly, is engineering education.

What then is the special nature of engineering education on the Cornell campus? The College of Engineering has long been known as a "tough" school, and it grows more so. It is certainly among the most demanding; the work is hard, the load is heavy, the hours are long. We do not coddle our students; the grading is severe and the faculty expects a boy to do a man's work. Unlike the boy in the technological institute who with other prospective engineers and scientists enjoy a degree of blissful segregation in his own sort of ivory tower, the Cornell engineer, happily for him but at real cost, lives in a veritable microcosm of young people which is as varied as their many talents and as broad as their world wide geographical distribution. The proverbial greener pasture is always in his view, tempting him from the rigors of his own professional preparation, and, if this were not enough, the lure of a kaleidoscopic program of extracurricular affairs tempts him unceasingly, often beyond his capacities to enjoy it. Not everyone can

thrive on this stage where academic discipline is arrayed against the distractions of play and of the vast world of knowledge and experiences beyond the confines of the professional preparation he has, at least tentatively, chosen for himself. And so it is that many students have fallen by the wayside, creating the traditionally high attrition rate of this and other engineering colleges, only about half of which is attributable to academic failure resulting from some flaw in intellectual capacity or shortcoming in scholastic preparation.

I have tried to sketch for you the salient characteristics of engineering education and to some extent of our own college of engineering. Basically, the admissions problem in engineering is not only to find bright people, but bright people who will thrive rather than wither in a professional program in the Cornell setting. In the short time remaining I shall pinpoint two aspects of this problem which I believe go to the heart of our admissions procedure. First, I want to speak about the need for vocational decision by freshman engineers; second, I shall say a word about the importance of non-intellectual factors in our admissions work.

Of the high school students who go on to college, those in engineering are among the few whose collegiate program demands a firm choice of vocation beforehand. The prospective lawyers, doctors, teachers, business men, and other may defer this decision for two years or more until a time when added maturity and experience enable them to make a better choice. Faced with this need for early decision, if engineering is a consideration, many boys refuse to commit themselves and go into liberal arts, while others, enter engineering with their fingers crossed and with only the flimsiest motivation. Either decision leads to increased attrition in engineering. Is there, then, any way in which a boy who thinks he might want to be an engineer can defer this decision for a year or two? I believe so, and I believe it would help to solve one of our major problems in admissions work.

Although we can expect few valid vocational decisions among teenagers, we can, I believe, identify a group which is highly able and interested in mathematics and science. Many of these young people know only that they want to use these attributes, but whether as scientists, engineers, teachers, or whatever else, they have little idea. As a result, some matriculate in liberal arts and others in engineering, only to find in many instances that they are off on the wrong track and must face the sticky problem of transferring later to another curriculum. Every year we see boys in engineering who ought to be in liberal arts, or arts students who should be in engineering, but the transfer difficulties are considerable and even where they can be overcome, time and cost are usually added to the student's program of higher education.

At Cornell, I believe we could do one of three things to remedy this situation. Each involves focusing the immense resources of the University, without respect necessarily to present administrative lines, on this specially designated group of students who somehow want to utilize their high level capabilities in science and mathematics. The proposals which follow are my own and do not reflect any official position of the College of Engineering, where, to my knowledge, there has yet been no formal discussion of any one of them.

The least disruptive approach to our problem would be a joint effort by arts and engineering to work out a plan for a proper exchange of students up to the end of two years, thus permitting the arts student who thought he wanted to be a scientist to transfer to engineering if he discovers this to be his real objective; or, on the other hand, permit the boy who first thought he wanted engineering to transfer to arts if he discovers, after a fair trial, that engineering is not for him. The Division of Unclassified Students is already a partial recognition of this proposal.

A second alternative would be, as instituted in some universities, to place all science and engineering under one administration. This would permit prospective scientists *and* engineers to matriculate in the same administrative division with prospects of a basic common curriculum for both and an advisory system which would facilitate their ultimate choice of professional objective. Here again, closer cooperation between arts and engineering in the interest of this science-mathematics oriented group of students would ultimately be necessary in planning curricula beyond the introductory stages.

A third possibility for these students might be a common University curriculum for one or two years, enabling them to defer until the end of this trial period the question of becoming scientists via the Arts College or degree candidates in some branch of engineering, depending upon their self-discovery and development during this time, and augmented by the assistance of capable advisers. Under this plan, these students would enter the University not as arts students or engineers, but as a special group to be assigned later to one or the other college at an advanced level.

Inherent in any of these plans is recognition of the fact that certain students cannot, as freshmen, intelligently decide between arts and engineering. Each would promote the concept of Cornell as a *Uni*versity instead of the *Multi*versity as it was recently referred to by Cornell's eminent professor in Industrial and Labor Relations, Milton Konvitz, and each would require some redefinition of the admissions problem for engineering, and to some extent for arts.

Finally, I shall conclude with a brief reference to the problem of identifying and measuring those personality traits which would permit us to admit students to the College of Engineering capable of bringing to fruition the high intellectual capacities the psychologists and educators have enabled us to discover within them. Bright as any student may be, his success or failure in the particular environment we create for him still depends largely upon factors such as energy, industry, motivation, study skills, emotional balance, and other traits which so far have eluded or baffled the psychometrists, those psychologists who attempt to measure human characteristics.

One solution to this problem, which of course is in one sense no

answer at all, would be to change the environment of the College; this would simply call for a different constellation of traits. On the other hand, the College of Engineering might well consider some changes in curriculum, in grading, in the advisory system, and probably in some other ways which would result in a climate favorable to a greater number of students without compromising its standards or academic and professional aims.

However we might change the College, it will always have a character which will favor the development of certain individuals and even blight the development of others. We shall, therefore, always be seeking certain types of students whose non-intellectual traits as well as their brains favor their success here. We must I think pursue the psychologists relentlessly in a quest for measuring sticks to weed out beforehand the applicants who are by nature incapable of adjusting to the demands we impose.

A last alternative, and perhaps the most realistic for now, is to be as forthright as possible, in our bid for students, in asserting clearly what we believe to be the true nature of the College and its rigors, hopeful that we may turn away those with enough insight to realize that they are not cut out for this particular college climate, at the same time inducing those who should do so to cast their lot with Cornell.

I am sure you must now realize from what I have had to say to you that this business of admissions is much more an art than a science and promises to be so for some time to come. Our problems in engineering are much greater than I have indicated in this talk, so at least you can be thankful to have been spared so much.

Editor's note: Donald H. Moyer, director of the Office of Student Personnel of the College of Engineering, delivered the above speech to the Cornell University Council on October 7, 1960. Mr. Moyer is a graduate of Harvard College, A.B. '27, and of the University of Michigan, M.A. (Psychology) '28.

Chances are you'll eventually be involved
in some way with specifications for:

AIR CONDITIONING
REFRIGERATION
HEATING
HEAT TRANSFER

and chances are you'll profit by knowing

DUNHAM-BUSH

the One Manufacturer providing
"one source-one responsibility" for all four.

DUNHAM-BUSH, INC.
WEST HARTFORD 10 • CONNECTICUT • U. S. A.

a year from today

where, how will you be applying your engineering knowledge?

Soon many positions will be made available to you and you must select a cornerstone for your career. Be analytical; you have a great deal to invest. Make sure the company offers room for personal growth plus the stimulus for achievement.

We urge you to examine Hamilton Standard, for we know our company offers the ideal environment for an engineering graduate. Long famous for its accomplishments in aerospace equipment, the company's Advanced Product Planning Program promises exciting expansion into entirely new industries. You will enjoy:

A VARIETY OF ENGINEERING ACTIVITY to sustain your interest, quickly broaden your experience and continually create advancement opportunities.

AN OUTSTANDING GRADUATE STUDY PROGRAM . . . tuition-paid program at accredited colleges and universities . . . Rensselaer Polytechnic Institute, University of Connecticut and others.

SMALL PROJECT GROUP APPROACH to assignments give you a sharper conception of the total problem and the evolution of each product.

DESIRABLE CONNECTICUT LIVING in a picturesque country setting, yet near New York and Boston. Excellent schools and housing.

• • •

Ask the Hamilton Standard campus representative every key question concerning your career. In the meanwhile, send for your copy of our 40-page brochure, ENGINEERING FOR YOU AND YOUR FUTURE. Write: R. J. Harding, Administrator–College Relations

BREATHING SYSTEM FOR THE B-70 BOMBER

A highly sensitive air induction system produced by Hamilton Standard will help this mighty aircraft attain speeds of over 2,000 miles an hour and altitudes to 70,000 feet. Design and development of this complex system underscores Hamilton Standard's capability in the fields of aerodynamics, hydraulics, electronics and electro-mechanical controls.

HAMILTON STANDARD DIVISION

an organization dedicated to *Scientific and Engineering Excellence*

UNITED AIRCRAFT CORPORATION

WINDSOR LOCKS, CONNECTICUT

When writing to advertisers please mention the CORNELL ENGINEER.

TITANIUM—
TITAN OF THE METALS

by William Smallwood, ME '61

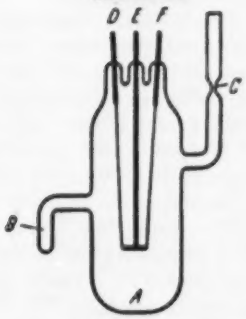
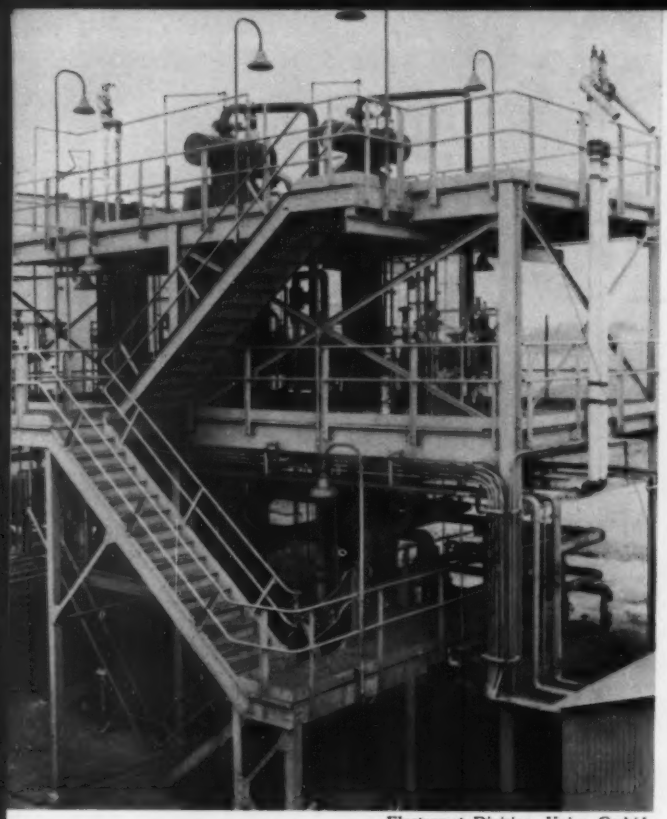


Diagram of the original apparatus used by de Boer and Fast for the preparation of pure titanium and zirconium: A, position of crude metal within envelope; B, side tube containing iodine; C, evacuation tube with sealing construction; D, E and F, electrodes sealed through glass envelope which support the fine tungsten wire filaments.

—from TITANIUM by A. D. McQuillan and M. K. McQuillan



Electromet Division, Union Carbide

1. DISTILLATION COLUMNS cut out impurities in $TiCl_4$ introduced by moisture and oxygen from air.

Electromet Division, Union Carbide

2. COOLING STATION: Cold air is blown around 14-ft.-by-3-ft. reactor for about three days.

The discovery of titanium is credited to the Reverend William Gregor, who, in 1790, identified it as a major constituent of a black magnetic sand found in Cornwall, England. In 1795, M. H. Klaproth found agreement between his analysis of Hungarian rutile (TiO_2) and that of Gregor's sand (ilmenite, $MgTiO_3$). Klaproth christened the element after the Titans, "first sons of the earth". Both the element and its oxide remained mere laboratory curiosities until late in the 19th century when attempts were made to isolate the pure metal. In 1918 titanium dioxide became commercially available as a white paint pigment.

Titanium is the ninth most abundant element in the earth's crust and comprises 0.62 per cent of its total. The richest sources of titanium are the minerals ilmenite, rutile, arizonite, perovskite and titanite. In addition, various titanium compounds are found in igneous rock, soils and clays, coal and oil, fresh and sea water, meteorites, the sun, many stars, most plants and many animals. The Russians drink it in their milk; it is present in our teeth and flesh; Pennsylvania anthracite has it; and sand beaches all over the world have from one to thirty per cent titanium.

In spite of its wide occurance, there are only a few deposits large enough to make recovery economical. Virginia, North Carolina, New York, Minnesota, Rhode Island, Montana, Colorado, California, Arizona and Wyoming have such deposits. Norway, Canada, Russia, Sweden, Africa, and most Asian countries also have large workable ore deposits. The world's production of titanium ores was over 600,000 tons in 1947, more than half of which was produced in the United States. In 1956, American paints contained over 500,000 tons of titanium oxide pigment. It is interesting to note that no production data is available from the U.S.S.R.

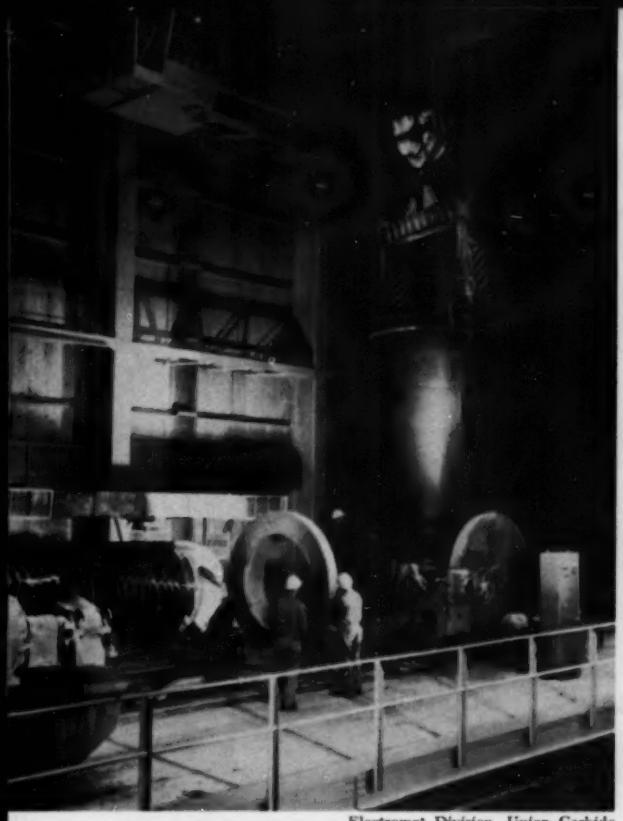
In the first half of the twentieth century, many attempts were made to find a feasible method of producing the metal. In September, 1948, DuPont offered 99.5 per cent pure titanium sponge at five dollars per pound. At this time the production rate was one hundred pounds per day. The year 1948 saw less than ten tons of the metal produced to satisfy the demand; primarily that of metallurgical research. Chemists and metallurgists had already shown that titanium and several of its alloys possessed superior corrosion resistance, strength and creep properties.

The Defense Production Act of 1950 authorized the building of a brand new titanium industry to supply military aircraft needs. Research grants, tax allowances and special amortization programs were used to spur the growth of "the wonder metal" industry. After many government demand increases, metal production capacity reached forty thousand tons per year in 1958. In addition to the two dollars and fifteen cents per pound of sponge, the government spent about three hundred million dollars on the entire program, with 20% of this going into research. A stockpile consisting of thirty-one thousand tons of high grade sponge is expected to reach a peak by December 31, 1961.

The industry's first six years saw higher output, steadily increasing capacity, tremendous improvements in quality, and technical

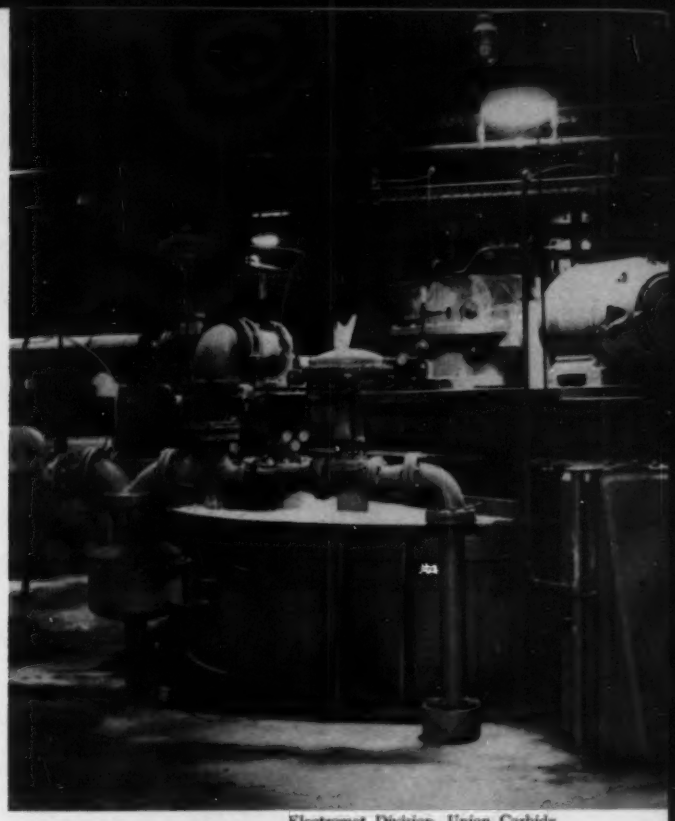
---

William Smallwood is a fifth year mechanical engineer. His article was written as part of the requirement for the University's 1242 materials course.



Electromet Division, Union Carbide

3. SPALT REMOVAL: Horizontal Boring machine (left) cuts out solid mixture of Ti sponge and NaCl.



Electromet Division, Union Carbide

4. LEACH TANKS: Slightly acidic (HCl) water leaches impurities from Ti sponge in rubber-lined tanks.

knowledge, and generally lowering prices. As a reward for such phenomenal progress, the industry was hit with a sharp cut in government buying and the great recession of 1957. The wonder metal was now called "the dismal flop".

The potential civilian market was not easily distracted from the much cheaper stainless steels and nickel alloys. Claims of great increases in service life and other well founded advantages of titanium and its alloys were ineffective in building new markets. A major reason for this problem was that, outside of aircraft applications, the metals had, as yet, not been thoroughly field tested. Although present demands are up, the five dollars to twelve dollars per pound price on standard mill products is discouraging. Research efforts are now being directed towards developing alloys, for specific applications, which may be more readily accepted in solving critical industrial problems.

Crystal structures

Titanium exists in a stable hexagonal close packed alpha phase at room temperature. Above transition temperature, variously given between 880 degrees C and 900 degrees C, it shifts to a stable body centered cubic beta phase. Photographs of X-ray diffraction patterns in $TiCl_4$ vapor indicate that the atomic radius of Ti is 1.54 Angstroms.

It has been observed that the presence of hydrogen in the titanium crystal lattice gives a nearly face centered cubic structure with the hydrogen in an interstitial solution. Dissolved nitrogen and oxygen also tend to distort the basic crystals. Alloying elements generally form a substitutional solution.

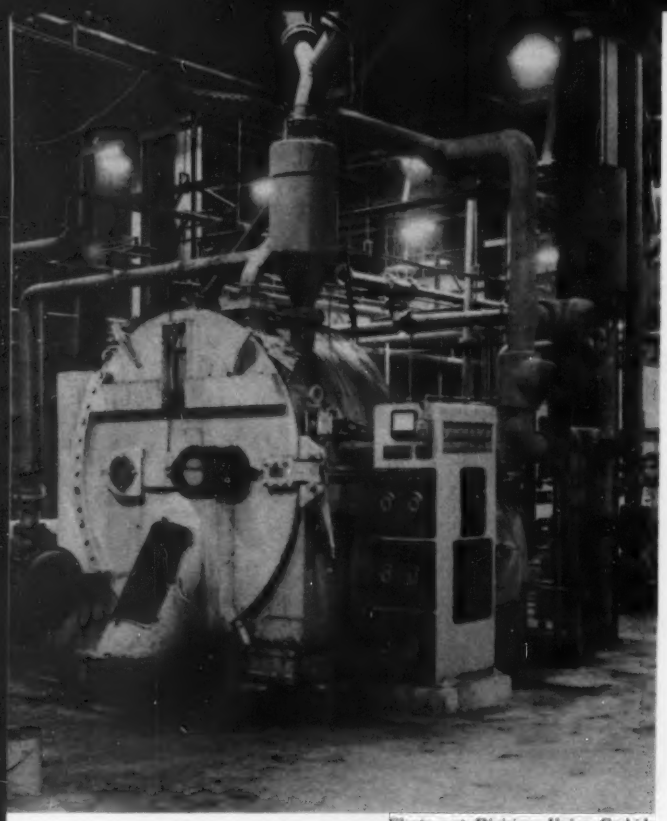
Chemical properties

Pure titanium metal is extremely reactive and even explosive if exposed to air, steam or boiling HNO_3. The powdered or granular forms are by far the most dangerous although hot solids or liquid melts are equally dangerous. Titanium and zirconium are the only metals known which will "burn" in nitrogen. Titanium oxides, halides, nitrides, carbides, sulfides and sulfates are readily formed at low temperatures. Several of these compounds are reduced in the various titanium metal production processes.

The superior corrosion resistance properties of the highly reactive titanium metal are explained on the basis of films. Primary oxide films formed in air are effective against some corrosive atmospheres while in others, a secondary film is formed after the oxide film is dissolved. Titanium is not effective in resisting HF, strong H_2SO_4 or aqua regia. The passivity of titanium is destroyed by all non-oxidizing acids. If the electric potential of the titanium (in these acids) is raised sufficiently, its anodic polarizing ability stops the attack and induces the regrowth of protective films. In cathodic protection applications (especially marine), platinum coated titanium anodes have had some success but are currently undergoing further service tests.

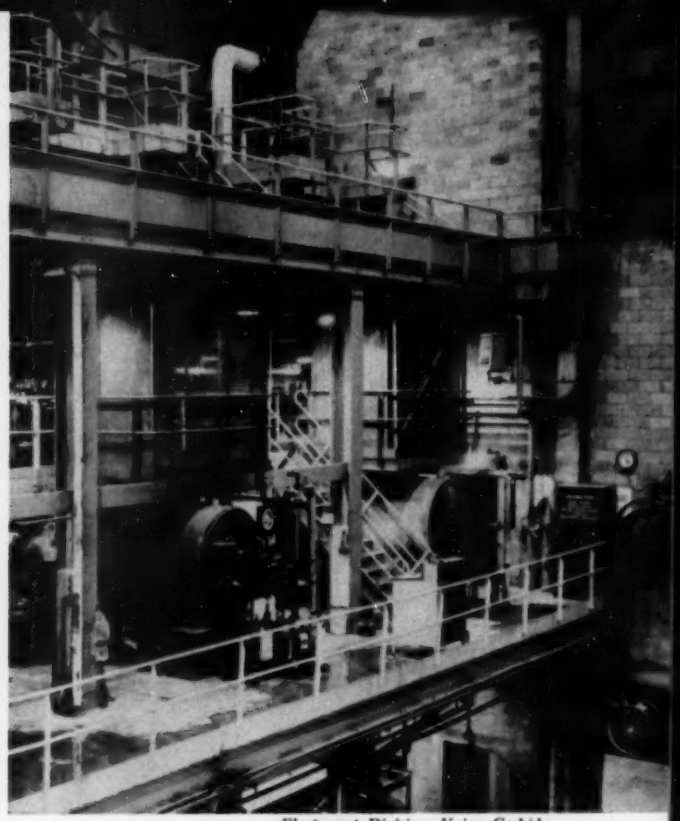
Titanium couple corrosion problems were encountered in many of the first military aircraft applications. The metal was used as a substitute (mostly for nickel), since the aircraft designs were completed prior to the completion of the titanium production facilities. Corrosion rates are increased when Ti is coupled to steel alloys, aluminum alloys, copper and monel. This corrosion usually induces stress concentrations at the joints.

Hydrogen, nitrogen and oxygen all diffuse quite readily into titani-



Electromet Division, Union Carbide

5. CENTRIFUGAL: Brine is separated from titanium sponge in these 60-in.-dia. horizontal basket centrifugals.



Electromet Division, Union Carbide

6. VACUUM DRYER: First steam, then water passes through dryer jackets to dry and cool titanium sponge.

um metal. At elevated temperatures (1400 degrees F) the metal has been observed to absorb up to twenty per cent oxygen by weight. Both hydrogen and nitrogen may remain dissolved at or near the surface, allowing them to be expelled in vacuum annealing. Both of these gases cause severe surface hardening.

The relative resistance of titanium to various corrosive atmospheres has recently been determined in tests conducted by the Columbia Southern Chemical Corporation. The entire program involved testing 2300 standard specimens of 40 different metals and alloys in nearly 150 different environments. It was observed that, in general, extremely high purity titanium showed no significant improvement over more standard purity specimens. It was also observed that, while zirconium was imperturbed in dry Cl_2, titanium behaved in exactly the opposite fashion. Other examples of the complementary nature of these metals were also observed.

Sponge Production

The process of obtaining a pure metal product from the various mineral sources of titanium presents one of the most complex and challenging problems that engineering technology has ever coped with. Much of the complexity is due to the requirement of high purity intermediate materials such as titanium tetrachloride, sodium and magnesium. These raw materials are usually reacted under vacuum or inert atmospheres. Handling the molten reactants and products also presents a major problem. The resultant titanium sponge requires special vacuum melting and casting procedures. The metal ingots must be specially treated to avoid massive scale formation and gaseous embrittlement.

Titanium tetrachloride is made by the thermal chlorination of rutile in the presence of carbon. The inherent impurities of this process are: $SiCl_4$, $VOCl_3$, $FeCl_3$, $AlCl_3$. All of these must be removed. Distillation is used to remove the $FeCl_3$, and $AlCl_3$. The $VOCl_3$ is precipitated and filtered out prior to the distillation process. Fractional distillation is used to separate $SiCl_4$, CCl_4 and HCl. The final product may still contain some $SiCl_4$ and Sn but has a purity of about 99.98 per cent. The $TiCl_4$ must be stored under an argon blanket to protect it from water vapor, oxygen and nitrogen. With the rising cost of rutile, it is probable that the $TiC1_4$ will eventually be produced from cheaper ilmenite, even though it will require more chlorine due to the increased amount of iron.

A popular way of obtaining magnesium, which is the reducing agent in the Kroll process, is to electrolytically separate $MgCl_2$ which can be obtained as a by-product of the Kroll process. The cast magnesium ingots must be surface cleaned and pickled in HCl prior to using.

Sodium is usually produced in the Downs process in which molten sodium and calcium chlorides are electrolyzed at six hundred degrees C. Filtration at temperatures above the sodium melting point removes all but a small percentage of the calcium and some smaller amounts of potassium and oxygen. Although from six to forty parts per million of oxygen are normal, these limits are at least tolerable in producing titanium. The sodium is shipped in special tank cars under a blanket of high purity argon.

The Kroll process is based on the thermal reduction of $TiC1_4$ by molten magnesium. The reaction is strongly exothermic and goes near-

ly to completion at equilibrium. The reaction is carried out in a crucible type reactor which must be heated in a furnace at the start and end of the reaction in order to maintain the operating temperature. MgC_2 is drained off several times during the reaction and an argon atmosphere must be maintained. About 85 per cent of the magnesium is consumed. Attempts to use the remaining magnesium cause $TiCl_3$ and $TiCl_2$ to be produced, thus decreasing the titanium yield. The largest Kroll reactor now operating produces three thousand pounds of titanium sponge per batch.

The most modern sodium reduction installation is Electromet's plant in Ohio. The plant's full capacity is 7,500 tons per year and consumes about 18,000 tons of sodium annually. Although the two processes differ in many particulars, the sodium reduction process is basically a Kroll process.

Solid sodium is melted by hot oils and pumped from the tank cars. The liquid sodium is moved through a weighing process and then to the reactors. Both resistance and induction heating methods are used to keep the metal liquid. The sodium and distilled $TiCl_4$ are simultaneously admitted to argon filled reactors which have been placed in special furnaces. Each reactor produces about a ton of titanium sponge during the eleven hour reaction. The reactors are removed and cooled for three days. The solid mixture of titanium and sodium chloride called spalt, is removed from the reactor by a horizontal boring machine. After being leached, centrifuged and vacuum dryed, the semipowdered sponge is blended into large uniform quality lots. Extreme care is necessary to insure high purity reactants, for this is the only way that high purity sponge can be made.

Ingot Conversion

Conventional melting techniques cannot be used to convert titanium sponge or granules into a massive form. Molten titanium not only will react with all known furnace refractory materials but it also reacts chemically with air and carbon. Consequently, inert atmosphere or vacuum electric arc melting furnaces of various kinds are used. Since vacuum metallurgy has reached an advanced stage, the vacuum arc melting furnace is not likely to be replaced soon. Consumable electrodes carrying up to twenty-five thousand amps are used to produce fifteen to twenty inch diameter ingots. Each ingot is melted twice. Since the electrodes, vacuum furnace and casting furnace are all water cooled, there is a tremendous explosion hazard. Remote optical and television systems are used in order to insure safe operation in titanium casting.

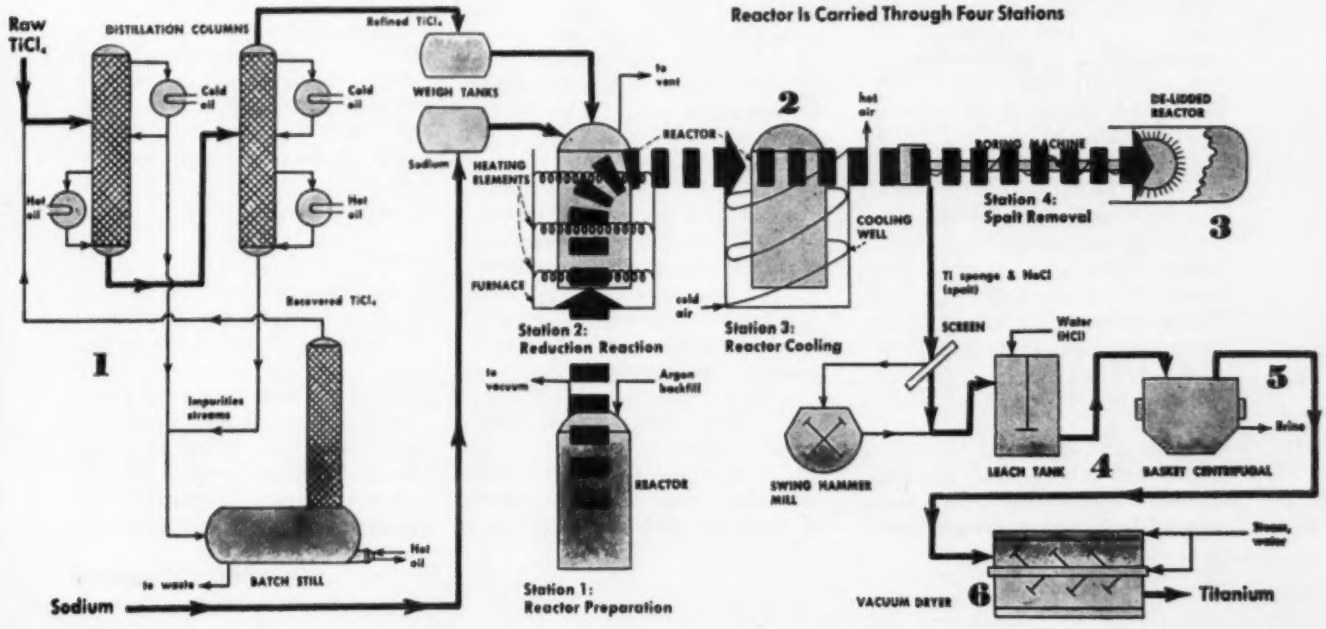
In the initial development of the titanium industry, the government failed to engage in active research or industry assistance aimed at developing methods of treating the high quality ingots that were available. Consequently, steel fabricators were left with the task of finding out all about titanium, the hard way. Most of the standard metal forms (rod, bar, sheet, wire, billet, tube, etc.) are now available in reasonable qualities, but at somewhat high prices.

Titanium scales are not protective and are freely penetrated by oxygen, nitrogen and hydrogen. Thus, all hot working processes must be carried out as fast as possible and at the lowest possible temperatures. Most descaling processes encourage hydrogen absorption, but scale removal is absolutely necessary if ideal mechanical properties are to result. The hydrogen, however, can be easily removed by vacuum annealing the final product. (Recent tests have shown that hydrogen in excess of one hundred parts per million will cause cracking or tearing following sheet forming operations. Quenching the titanium will force the hydrogen into a solid solution and tearing becomes less likely.

The fact that surface scale has over one hundred times the resistance of pure titanium presents definite welding problems. A variety of different scales can be formed depending on the formation

The flow sheet for the sodium-reduction method of producing titanium.

Chemical Engineering March 10, 1958



temperature. Numerous descaling methods are used but many tend to pit surfaces and promote hydrogen embrittlement.

Titanium wire must be plated with silver or nickel or else painted (with a surface reactive paint and lubricant) to avoid galling.

Fabrication Characteristics

Titanium sheet metal has generally suffered from lack of uniformity; a significant problem. High yield strengths, low uniform elongation limits and anisotropic properties are at the heart of the problem. Sheet bending operations suffer from springback so that hot forming is frequently necessary. Blanking operations are similar to, but require more force than, one-quarter hard 18-8 stainless steel. Hammer forming and rubber forming have been successfully applied at temperatures of 650 to 900 degrees F. The most successful forming operation thus far has been stretch forming, which can achieve up to 13 per cent elongation at room temperature.

Titanium spinning has been done at temperatures above one thousand degrees F, while drawing has been successful in both the hot and cold condition when special lubrication techniques are employed.

Commercial titanium and several of its alloys can be forged, but not without some severe restrictions. Special die designs and more stages are required than for either steel or aluminum. Rapid work hardening restricts forging to rather thick section pieces. Temperatures from 1700 to 1800 degrees F. are recommended. Since titanium resists rapid deformation much more than slow deformation, cracking can be avoided by making light reductions.

Failure to find a suitable mold has kept casting production at a minimum. Both graphite and water cooled copper molds have been used but not economically, since the molds must be enclosed in the same inert atmosphere or vacuum as the melting furnace in order to avoid severe contamination of the titanium.

In general, parts made in the above and other special methods have not been available on a commercial basis. Information is therefore either nonexistent or only partially proven. It will therefore be a long time before the ten year old titanium fabrication art will reach the "handbook" stage.

Processing Characteristics

Commercial titanium is usually compared to 18-8 stainless steel as to machinability. Turning is the least complicated operation. Milling suffers from high tool attrition due to chip welding. Drilling requires low speed, heavy, positive feed of short drills. Tapping, reaming and sawing have been more or less standardized though each operation requires a different coolant.

The greatest difficulty with grinding operations is that the titanium tends to dissolve most wheel abrasives. Titanium dust from grinding is quite explosive, so wet grinding must be used. Surface stresses are quite likely, due to the low thermal conductivity of the titanium. Electroplating procedures were developed early in an attempt to reduce galling (very high coefficient of friction) and have since been extended to provide titanium with chromium, copper, nickel and aluminum finishes. Painting and dying (after surface anodizing) are also used to provide desired surface finishes.

Joining of titanium alloys is difficult at best. Resistance and inert gas shielded arc welding have been successful to some degree. Brazing and adhesive bonding give good results, but soldering is unsatisfactory. Arc welding requires very high purity helium or argon atmosphere, because the addition of as little as 0.25 per cent of nitrogen or oxygen will produce severe embrittlement of the weld. Carbon has a similar effect. High pressure, high penetration spot welding is very satisfactory though it requires about 50 per cent more current than with other metals. Standard aluminum flash welding machinery has also been successfully applied to titanium. Induction brazing techniques are preferred to furnace brazing. One hundred thousand pounds per square inch adhesive bonds have been obtained using special surface preparation techniques. Mechanical fasteners (nuts and bolts) must be coated with teflon or a copper flash to prevent galling. Close tolerances must be held to obtain good upsetting of titanium rivets.

Physical and Mechanical Properties

It should be noted that titanium has a strength to weight ratio which compares with many steels and exceeds the best aluminum and magnesium alloys. The creep properties are also superior to those of aluminum at temperatures where aluminum is useless.

Applications

Research has indicated that titanium can be used to advantage in a multitude of strength, corrosion and electronic applications. In each group, special alloys have been developed to improve the properties of commercial titanium. Lack of wide-spread public acceptance has prevented both price reduction and further development.

It is impossible to describe all of the current and suggested applications for titanium, but a token list will be presented under each of the categories suggested above.

Strength applications include: aircraft engine firewalls, aircraft skins and ribs, jet engine parts, engine cowlings, wire cloth, and high speed pump components.

Corrosion applications include: marine exhaust silencers, futuristic automobile bodies, chemical transfer equipment, orifice plates, jets and nozzles, and chemical filtering equipment.

Electrical applications suggested are: vacuum tube heater, cathode plate and grid connections, radar and industrial power controls, and mercury switch components.

Other applications of interest are: orthopedic surgical plates, pins and splints, structural building materials, decorative fittings on boats, cars and trains, and steel and aluminum alloying agent.

Summary

The titanium metal industry is less than ten years old. The industry, built to supply titanium for government aircraft, has been plagued by normal growing pains, recessions, poor public acceptance due to high costs as well as a host of technical difficulties.

Various oxides of titanium are converted to a tetrachloride and

then reduced by molten magnesium or sodium to give a powdery material called sponge. Nearly all processes which occur at elevated temperatures require inert atmospheres or vacuum treatments. Oxygen, hydrogen and nitrogen all cause severe scaling or surface embrittlement.

Due to various surface films which form, titanium is extremely resistant to most corrosive atmospheres. Certain alloying agents tend to increase the inert properties of titanium. Titanium plating is currently being developed in order to avoid high costs and still obtain the metal's superior corrosion resistance.

Titanium can be formed by most conventional techniques, although in most cases modifications are necessary to prevent surface galling or cracking. Titanium has a very high strength to weight ratio, comparative to many stainless steels and superior to aluminum, magnesium and nickel alloys. Titanium retains its strength at temperatures where aluminum is useless. Titanium's creep properties are also superior.

Current and planned titanium applications are not limited to any particular field. Chemical process and marine industries, along with the aircraft industry, currently use most of the titanium produced in this country.

BIBLIOGRAPHY

1. Barksdale, J., "Titanium", Ronald Press, 1949
2. Gray, J. J. and Carter, A., "Chemistry and Metallurgy of Titanium Production", The Royal Institute of Chemistry, 1958
3. Tyler, P. M., "Growth of the Titanium Industry", Metal Progress, V 74, July 1958, pp 97
4. Stephenson, W. B., "Descaling of Titanium", Metal Progress, V 73, March 1958, pp 87
5. Vigor, C. W., Hornaday, J. R., "Tear Test for Titanium Sheet", Metal Progress, V 73, April 1958, pp 103
6. Gillett, H. W., "The Behavior of Engineering Metals", John Wiley & Sons, 1951
7. Evans, V. R., "The Corrosion and Oxidation of Metals", St. Martins Press, 1960
8. "Titanium vs Steel, A Symposium", Journal of Metals, V 12, Feb. 1960, p 123-151
9. Forbath, T. P., "Sodium Reduction Route Yields Titanium", Chemical Engineering, 10 March 1958, p 124
10. "In Plant Tests Confirm Corrosion Resistance of Titanium", Union Carbide Metals Review, Summer 1959
11. Lytle, A. R., "Outlook for Titanium", The Analysts Journal, June 1955
12. Everhart, J. L., "Titanium", Materials of Design Engineering, Oct. 1957, p 149-168
13. "Making the Most of Titanium in the Chemical Process Industries", Crucible Steel Company of America, 1959 (This reference appears as appendix F of this report.)
14. McQuillan, A. D., and McQuillan, M. K. "Titanium", London Butterworths Scientific Publication, 1956
15. Skinner, G., Johnston, H. L., and Beckett, C., "Titanium and its Compounds", Herric L. Johnston Enterprises, 1954

EDITOR'S NOTE

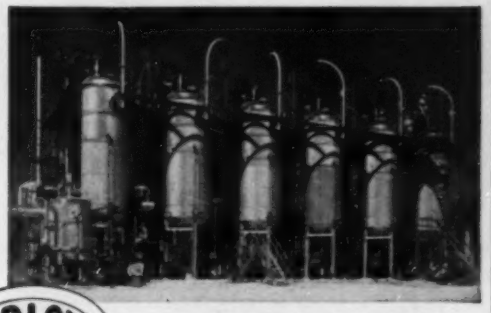
Editor's Note: Titanium (Crucible 130 AM) is used for a multiple force fit pressure vessel by Professor Arthur Ruoff in Cornell's Thurston High Pressure Laboratory. The titanium is used because the application requires a non-magnetic material and because it can be heat treated to obtain high strength. A three inch outside diameter vessel has been used with internal liquid pressures of 20,000 atmospheres or roughly twenty to thirty times the pressure at the deepest known spot in the oceans. The vessel is used for experiments in which the specimen to be studied is under pressure in a magnetic field.

The 400

Our pleasure is in serving you

400 College Avenue
Ithaca, N.Y.
Restaurant and Soda Bar

IN THE HEART OF COLLEGETOWN



FRICK

REFRIGERATING ENGINEERS

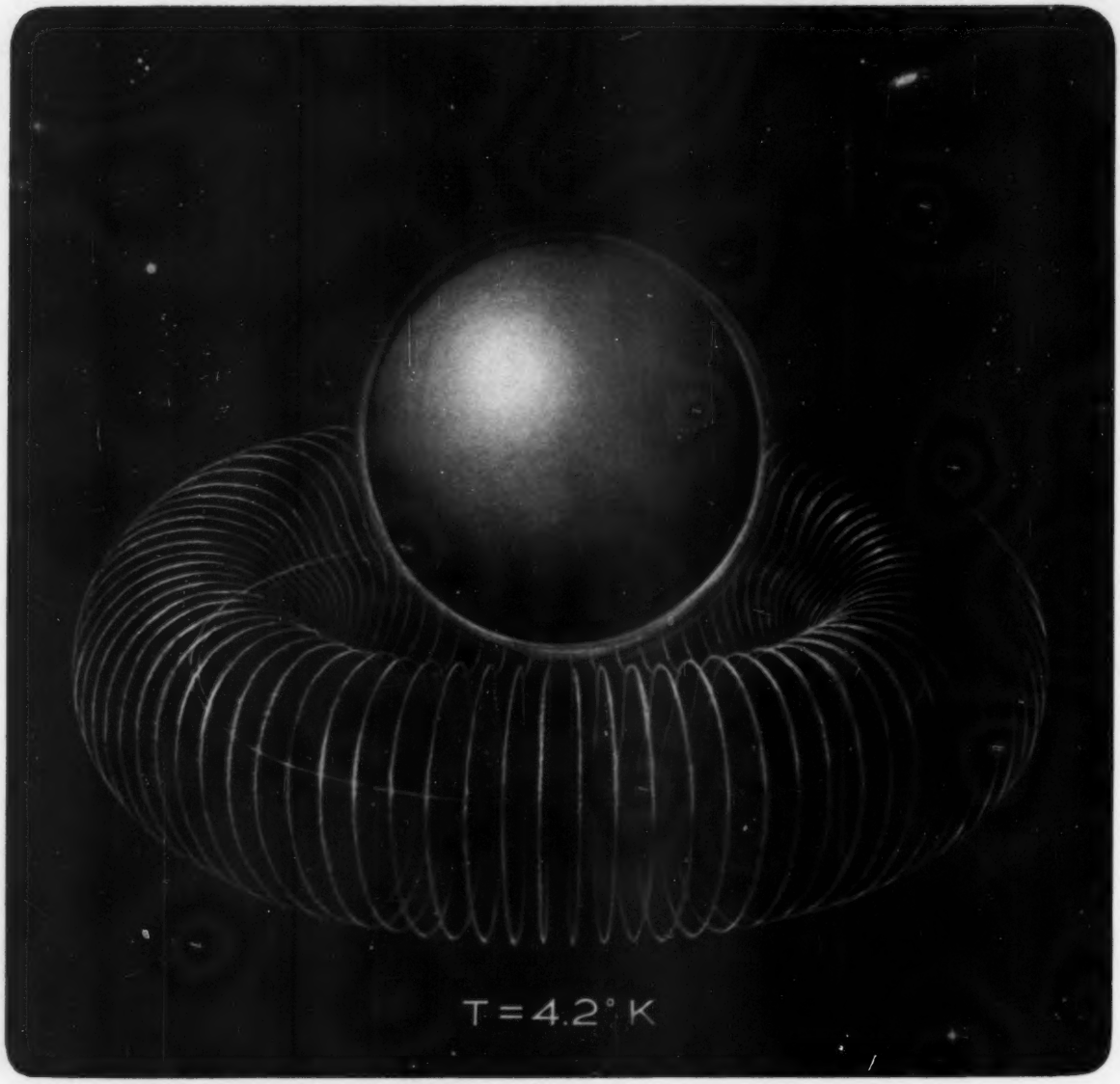
Have more than doubled the capacity of synthetic rubber reactors with an improved and patented cooling system—one of many Frick developments of vital interest to defense, to industry, and to business.

When you take the Frick Graduate Training Course you enter a growth program, with excellent pay and exceptional opportunities.

Get full details today from your College Placement Office or from

FRICK COMPANY
ESTABLISHED 1853
Waynesboro, Pennsylvania

IMPORTANT DEVELOPMENTS AT JPL



THE CRYOGENIC GYRO

A fundamentally new type of gyroscope with the possibility of exceptionally low drift rates is currently under development. The design techniques used in conventional electro-mechanical gyros appear to have been largely exploited. A break-through is needed, and the cryogenic gyro may well provide it.

The cryogenic (liquid helium temperatures, in the range of 4°K) gyro consists of a superconducting sphere supported by a magnetic field. The resulting configuration is capable of support in this manner as a result of a unique property of a superconductor. Exceptionally low drift rates should be possible. This cryogenic gyro has performance potential unlimited by the constraints of conventional electro-mechanical gyros.

This is just one example of the intriguing solid state concepts which are being pioneered at JPL for meeting the challenge of space exploration. In addition to gyro applications, superconducting elements are providing computer advances and frictionless bearings. The day of the all-solid-state space probe may be nearer than one realizes.

CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
A Research Facility operated for the National Aeronautics and Space Administration
PASADENA, CALIFORNIA

Employment opportunities for Engineers and Scientists interested in basic and applied research in these fields:

INFRA-RED • OPTICS • MICROWAVE • SERVOMECHANISMS • COMPUTERS • LIQUID AND SOLID PROPULSION • STRUCTURES • CHEMISTRY
INSTRUMENTATION • MATHEMATICS • AND SOLID STATE PHYSICS • ENGINEERING MECHANICS • TRANSISTOR CIRCUITRY

Send resume, with full qualifications and experience, for our immediate consideration

When writing to advertisers please mention the CORNELL ENGINEER.

Research at Cornell . . .

MACHINE SHOP SIMULATION

by Robert Sanderson, ME '65

What is the most economical way to run a machine shop and maintain satisfactory service to the customers? William Maxwell, B.M.E. '57, a member of the industrial engineering department of the Sibley School of Mechanical Engineering, has been working on this problem for three years by simulating shop operations on an electronic computer.

Mr. Maxwell and Bruce Johnson, B.M.E. '57, who is now at Northwestern University, started the project during the summer of 1958, as

Brad Smith

William Maxwell watches the results of the computations as they are printed by this IBM 407 Line Printer at the rate of 18,000 characters per minute.

a "project in digital simulation" sponsored by the Office of Naval Research. They were under the advisorship of Professor Richard Conway, Ph. D. '57. During the 1958-59 academic year, they were assisted by a candidate for a Master's degree and three fifth-year engineers. The University assumed part of the sponsorship, for the research was the subject of a Master's thesis and three engineering projects.

A real machine shop is divided into various departments, and each has a queue, a waiting list of jobs to be done. The shop Mr. Maxwell and Mr. Johnson set up was entirely on paper and in the form of a computer program. During the summer of 1958 they constructed a queue network simulator for an IBM 650, the University's computer. (This machine has since been retired. Its replacement is a Burroughs 220.) During the 1958–59 academic year they conducted a general investigation, trying twenty-four different methods of queuing. Last year Mr. Maxwell continued using the experimental approach in further application and modification of previous findings, but Mr. Johnson branched off into theoretical problems of queuing. They were sponsored by General Electric Company and a New York consulting firm, Touche, Ross, Bailey, and Smart.

Each of the methods Mr. Maxwell and Mr. Johnson tried dealt with one basic question: which job should be done first? Machine shops now use two main rules to determine queues: due dates and slack time. The due date rule is simply that the job must be finished by an assigned date, and the slack time rule means that due dates should be scheduled so as to keep work at a balanced level.

Of the 24 methods that were simulated, two are very promising. The more promising of this pair is the shortest operation rule. By this rule jobs that had the shortest processing times were chosen from the queue to be done first. If business was good, however, long jobs would be shelved quite a while or never done at all. Mr. Maxwell tried several modifications of this method in his experimentation last year. Truncation always seriously reduced the desirability of the shortest operation rule, but the modified rule is still the most promising.

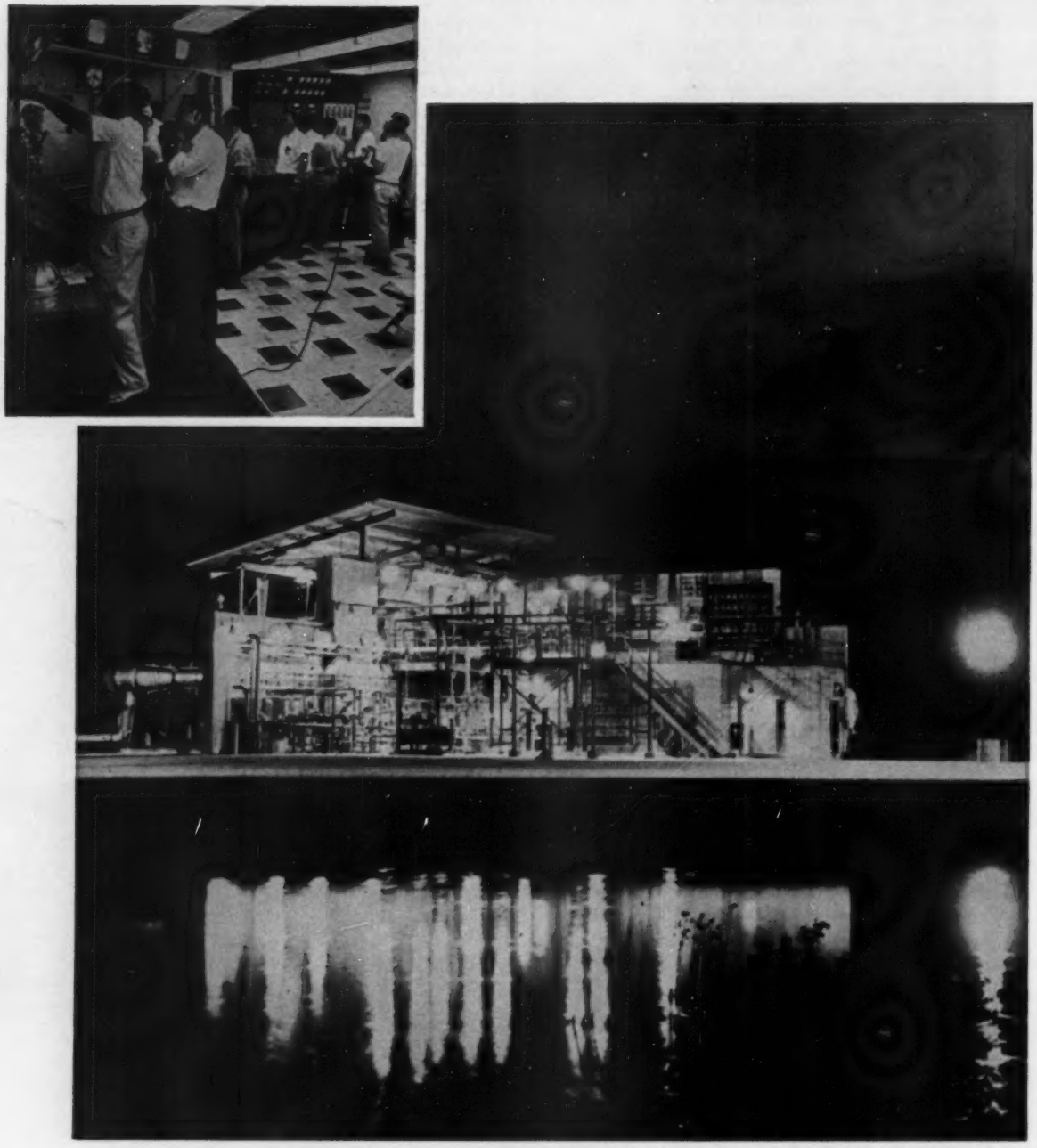
The second promising method of dispatching was anticipation. This is basically a critical queue rule: keep every department running at a certain minimum level by dispatching new orders to departments where the least work is anticipated. This rule of dispatching becomes much more complex than the shortest operation rule because a great deal more information is needed. The rule's main drawback, the requirement of so much data, some of which is very hard to obtain, is indeed a serious fault.

Mr. Maxwell believes that there is more promise in the shortest operation rule and that it can be applied to actual use. The rule, even with its fault of indefinite postponement of longer jobs, can be put into practice if accurate prediction of due dates can be devised, since customers will wait for their orders so long as the due dates are met. After he has studied production long enough to make the shortest operation rule practical, Mr. Maxwell will probably turn to studies of inventory.

Brad Smith

Richard Conway and William Maxwell supervise the operations of the Burroughs 220 Digital Computer from the control panel.

What would YOU do as an engineer at



Development testing of liquid hydrogen-fueled rockets is carried out in specially built test stands like this at Pratt & Whitney Aircraft's Florida Research and Development Center. Every phase of an experimental engine test may be controlled by engineers from a remote blockhouse (inset), with closed-circuit television providing a means for visual observation.

When writing to advertisers please mention the CORNELL ENGINEER.

Pratt & Whitney Aircraft?

Regardless of your specialty, you would work in a favorable engineering atmosphere.

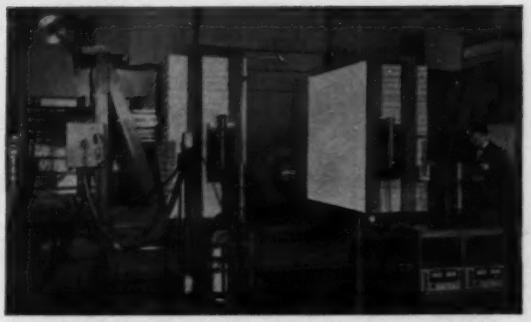
Back in 1925, when Pratt & Whitney Aircraft was designing and developing the first of its family of history-making powerplants, an attitude was born—a recognition that *engineering excellence* was the key to success.

That attitude, that recognition of the prime importance of technical superiority is still predominant at P&WA today.

The field, of course, is broader now, the challenge greater. No longer are the company's requirements confined to graduates with degrees in mechanical and aeronautical engineering. Pratt & Whitney Aircraft today is concerned with the development of all forms of flight propulsion systems for the aerospace medium—air breathing, rocket, nuclear and other advanced types. Some are entirely new in concept. To carry out analytical, design, experimental or materials engineering assignments, men with degrees in mechanical, aeronautical, electrical, chemical and nuclear engineering are needed, along with those holding degrees in physics, chemistry and metallurgy.

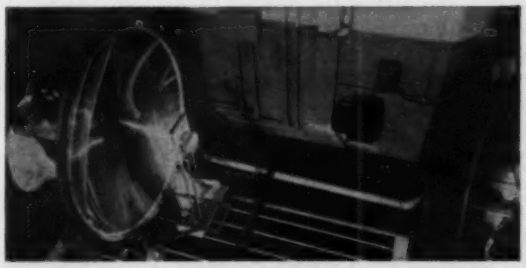
Specifically, what would *you* do?—*your own engineering talent* provides the best answer. And Pratt & Whitney Aircraft provides the atmosphere in which that talent can flourish.

For further information regarding an engineering career at Pratt & Whitney Aircraft, consult your college placement officer or write to Mr. R. P. Azinger, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.



At P&WA's Connecticut Aircraft Nuclear Engine Laboratory (CANEL) many technical talents are focused on the development of nuclear propulsion systems for future air and space vehicles. With this live mock-up of a reactor, nuclear scientists and engineers can determine critical mass, material reactivity coefficients, control effectiveness and other reactor parameters.

Representative of electronic aids functioning for P&WA engineers is this on-site data recording center which can provide automatically recorded and computed data simultaneously with the testing of an engine. This equipment is capable of recording 1,200 different values per second.



Studies of solar energy collection and liquid and vapor power cycles typify P&WA's research in advanced space auxiliary power systems. Analytical and Experimental Engineers work together in such programs to establish and test basic concepts.

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

CONNECTICUT OPERATIONS — East Hartford

FLORIDA RESEARCH AND DEVELOPMENT CENTER — Palm Beach County, Florida

When writing to advertisers please mention the CORNELL ENGINEER.

Faculty Profile . . .

PROFESSOR ROGER L. GEER

by Alden Speare Jr., EP '63

Most engineering students have come to know Professor Roger L. Geer of the materials processing department during their stay at Cornell. Many remember his snow white hair and thin rimmed glasses from their freshman course in machine tools. Mechanical engineers remember him from their course in production machine tools in the junior year.

Professor Geer, a Cornell graduate, has served in the Sibley School of Mechanical Engineering for over 20 years. During this time he has always extended a warm welcome to students in his office and has been willing to explain any problems which arise in materials processing.

Professor Geer grew up in the town of Marathon, New York, about 30 miles from Ithaca. He attended Marathon High School, where he participated in track and baseball, and played the clarinet in the orchestra. Besides these activities, he worked after school in a hardware store and later in a print shop to earn money for college.

In 1924 he entered the Sibley School of Mechanical Engineering at Cornell and worked his way through his education as an engineer's assistant for the New York State Department of Public Works. While at Cornell, he wore the uniform of the Big Red Band, which then consisted of duck pants, red sweaters, and sailor's caps.

Receiving his M. E. degree in 1930, he went to work as an industrial engineer for Perfection Stove Co. in Cleveland, Ohio. There he devised new methods for bookkeeping and designed assembly equipment for oil burning room heaters.

In 1935, Professor Geer moved back to the Finger Lake region and took a job as a methods engineer for Smith Corona Typewriters in Groton, New York. Here he did research in cutting fluids, assembly techniques, and safety methods.

He came to Cornell in September, 1939 as an instructor in descriptive geometry and engineering drawing in East Sibley Hall. In 1941, he became an instructor of materials processing and designed the equipment and course material for the gage laboratory. The gage laboratory at Cornell was the first to be established at any engineering school. After the war he was able to get much of the equipment for the laboratory from the ordnance department.

In 1943, he became an assistant professor and in the same year was made acting head of the materials processing department, a post which he occupied until 1948. Since that time, until this year, he has lectured for the machine tools courses and a course in production machine tools which he continues to teach.

Photo Science

Professor Geer

During these years, Professor Geer was active in many other fields. He was scoutmaster for the local scout troop for 4 years and still maintains that their method of teaching through small groups and individual practice is the best.

He was very busy during the war years, as a member of the Ithaca High School faculty, as an instructor in the evenings under the National Defense Program, as an instructor for the Ordnance Inspection Training Program, and as an instructor in first aid for the Red Cross in addition to regular assignments at Cornell.

In later years, he served as Secretary-Treasurer of the Southern Tier Section of American Society of Mechanical Engineers and then as National Chairman of the Committee on Inspection and Gaging for the Instrument Society of America. He was instrumental in founding the Ithaca chapter of the American Society of Tool Engineers and is presently vice-chairman of the organization. He has written several papers on inspection and gaging.

Presently, Professor Geer holds the title of Associate Professor of Materials Processing and handles the lectures and lab work for the production machine tools course. He also does special course work for several students interested in the field and especially enjoys working with foreign students. He is planning research on surface finish and super finishing and will investigate the effects of pressure, fluid, and other factors on finishes.

A Campus-to-Career Case History

Field assignments, plus theoretical lab work (above), keep Larry Carmody's engineering career stimulating.

If your future is engineering, put yourself in Larry Carmody's shoes

Lawrence M. Carmody formed some firm convictions about his future engineering career while a senior at Illinois Institute of Technology.

"I wanted to do significant work," he says, "and have a variety of assignments that would broaden me and keep my job interesting. I wanted to make good use of my schooling and express my own ideas. And, like anyone with ambition, I wanted all the responsibility I could handle and some genuine opportunities to keep moving ahead."

Larry got his B.S.E.E. degree in June, 1955, and went with Illinois Bell Telephone Company in Chicago. He first worked in the Radio and Special Services Group of the Transmission Engineering Division. There, in addition to receiving more advanced training, he:

- designed mobile radio systems
- did path studies of radio circuit routes
- worked on a special air-to-ground communications project for an airline
- did field work for a new, transistorized walkie-talkie system developed by Bell Laboratories.

Today, Larry is planning and designing statewide long-distance facilities involving microwave, carrier, and cable systems—projecting circuit needs as far ahead as 20 years. His recommendations often represent hundreds of thousands of dollars in equipment and facilities.

"Telephone company engineering is 'tops' in my book," says Larry.

Like to be in Larry's shoes? Many young college men are pursuing careers just as rewarding with the Bell Telephone Companies. Why not find out about opportunities for you? Have a talk with the Bell interviewer when he visits your campus—and read the Bell Telephone booklet on file in your Placement Office.

BELL TELEPHONE COMPANIES

MOLYBDENUM

by Richard F. Allen, ME '62

From the time of Aristotle, about 350 B.C., to the eighteenth century, much confusion arose in the use of the terms plumbago, graphite, galena and molybdaena. The term molybdaena is a Latinized form of the Greek word for lead and appears to have been applied by Aristotle and others to various things associated with lead, to lead oxide obtained as a by-product of cupellation and to natural lead ores.

One of the first references to molybdenum will be found in Agricola's *De Re Metallica* where the word molybdaena is used as an alternative to galena, molybdaena being looked upon as a variety of litharge. After Agricola's time the term molybdaenum was applied to substances resembling lead, such as graphite and what we now know as molybdenite (MoS_2). In his search for Latin terms for technical purposes, Agricola relied almost wholly upon Phiny and it is probable that the confusion between the terms molybdaena and galena originated then.

In the seventeenth century it was recognized that molybdaena and graphite did not contain lead, and those who experimented on molybdaena seem to have regarded it as a kind of zinc sulphide. The confused ideas which prevailed up to 1778 as to the nature of graphite and molybdenite were at length dissipated by the work of C. W. Scheele. He found that when molybdenite was heated with nitric acid a white residue was formed. Under similar treatment graphite remained unaltered. He later showed that the white residue consisted of an acid-forming oxide which we now know as molybdic acid. In 1782 P. J. Hjelm separated the metal from molybdaena by heating the oxide with charcoal and called it Molybdenum. He obtained the metal as a fine black powder, but could not fuse it into a button because the highest temperature obtainable at that time was far too low. Since the turn of the century the term molybdenite has been used for the mineral sulphide. It was not until 1893 that H. Moissan used the electric furnace to fuse molybdenum by heating a mixture of the dioxide and carbon at high temperature to obtain an impure metal containing about 92–96 per cent molybdenum.

The major use for molybdenum is in the manufacture of alloy steels. More than three quarters of the molybdenum produced has been applied for this purpose, either as molybdic oxide, ferromolybdenum or calcium molybdate. The uses of molybdenum in steel are now well understood, the principal advantages being improved hardenability, reduction of mass effect and increase in toughness, the avoidance of temper-brittleness and the maintenance of high temperature properties.

With the ever-increasing demand for engineering materials for use at very high temperatures, it is to be expected that there will be an increasing trend towards applications where molybdenum is employed either as the pure metal or as a molybdenum-rich alloy. This will be aided by the greater availability of molybdenum made possible by the opening up in recent years of the vast deposits in Colorado, its occurrence as a by-product in certain copper ores, and the development of arc-melting techniques for making large masses.

Production of the Metal

A method has been described for obtaining very rapid grain growth so that single crystals of high melting point metals could be made with comparative ease. The furnace construction was essentially a very thin wire through which was passed an electrical current so that a high uniform temperature was maintained. The wire was surrounded by a fused quartz tube from which the air had been evacuated. Andrade applied this method to the growth of single-crystal wires of alpha iron, and Tsien and Chow prepared single crystals of molybdenum 0.25 mm in diameter in this way. In a report by N. K. Chen, R. Maddin, and R. B. Pond, a method is described in which the basic idea of the Andrade furnace is utilized. However, modifications are employed so that large single crystals of molybdenum or of any refractory metals can be grown.

The furnace proper consists of a 2½ inch diameter fused silica

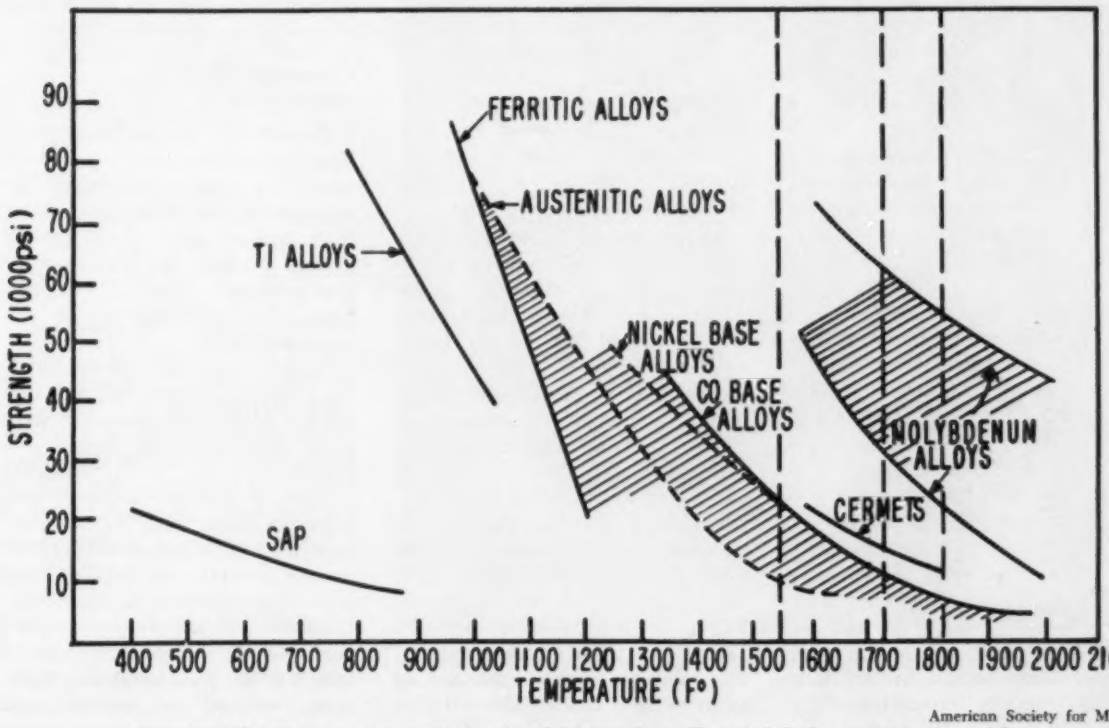
tube, 20 inches long, which is evacuated continuously at the bottom. Two water-cooled copper electrodes hold the specimen by means of collets held in place in the electrodes by set screws. After the specimen is mounted and the vacuum is secured, the lever arm is adjusted by means of the counter weight so that the bellows is at its relaxed position. This insures that the total weight of the specimen, the upper electrode, and the downpull of the vacuum are balanced by the horizontal beam. Any expansion of the specimen on heating should proceed freely, if other frictional forces can be neglected. During the time of heating the specimen, the beam is maintained in a horizontal position by turning the nut at the top; the rotation of the electrode is prevented by a key fitted into a groove. This arrangement proved very desirable in that buckling of the specimen during the high temperature treatment was avoided.

The power is supplied by a motor generator set with a capacity of 550 amps at a maximum of 24 volts. Results indicated that for a ¼ inch diameter, 6-inch long molybdenum rod, a current in the vicinity of 210 amps at 2.5 volts could heat the specimen up to an average temperature of 2000°C. The subsidiary external furnace is wound with nichrome so that the electric heating zone is a cylindrical band ½ inch wide. It can be raised or lowered by means of the attached motor whose speed may be varied by an electronic controller from 0.5 to 15 inches per hour.

The average temperature of the specimen can be measured from the change in its resistance with temperature. A linear relationship of specific resistance of molybdenum with temperature exists up to its melting point. Thus, when the total current is measured, together with the voltage drop across the specimen, the corresponding resistance can be used to indicate the average temperature. The current through the specimen is adjusted by controlling the field resistance of the generator with electric stoves and a rheostat. After the current and voltage have been stabilized corresponding to a particular average temperature of the specimen, this equilibrium condition can be maintained for a long time.

The modified Andrade equipment has overcome the limitations of the original Andrade method in that only very fine wire could be used with his equipment as a starting material. With the present arrangement, material of rather large size: ½ inch rods, can be converted into single crystalline form.

The very rapid grain growth observed in these experiments over the relatively short time employed is of great interest. Since both ends of the specimen are at room temperature, about 35°C, where the center section is maintained at a temperature higher than 2000°C, a very sharp temperature gradient exists in the specimen. It is not known whether the sharp gradient or the high temperature is responsible for the rapid grain growth, nor is it possible at the present time and with the present equipment to measure or calculate accurately the temperature gradient along the rod. A simple uniform variation of temperature was assumed and the average temperature resulting from this distribution was calculated. With this assumed temperature gradient the total average resistance assuming different lengths of rod was determined. By this method the temperature of the rod was calculated. There was little doubt



American Society for Metals

Comparison of stress to rupture properties of molybdenum base alloys with high temperature materials.

that the temperature at the center of the rod exceeded 2000°C when the average temperature for a length of 4 inches was measured at 2000°C.

Tsien and Chow, in their original experiments, used the subsidiary furnace to establish a temperature gradient. Without the use of the subsidiary furnace, single crystals never exceeded 2mm in length. However, it is probable that the external furnace has little or no effect on the final outcome of the experiments since the sharpest temperature gradient exists in the specimen itself as a result of the water-cooled ends. No observable difference in the results could be noted when the external furnace was used.

Physical Properties

The crystal structure of molybdenum at room temperature is body centered cubic. No evidence has so far been deduced from microstructural studies that there is an allotropic change, and thermal expansion measurements indicate that molybdenum retains the body centered cubic structure up to at least 2125°C.

S. S. Lu and Y. L. Chang have determined the lattice constant as 3.1403°A at 20°C; this was by an improved back reflection method claimed to be accurate to 1 part in 50,000, using a sample of Hilger molybdenum powder.

The lattice deformation caused by cold working gives estimated deviations of the atoms from their normal positions in the undistorted lattice of 1/50 of the interplanar spacing.

The slip planes and slip directions in molybdenum single crystals have been determined by L. C. Tsien and Y. S. Chow. The slip plane is (112) up to 300°C but (110) at 1000°C. The slip direction is (111) at all temperatures. The lower the temperature the more slip per slip plane and the closer the slip planes to each other.

In drawing molybdenum wire the crystals become oriented such that a face diagonal of the unit cell is parallel to the axis of the wire, the direction normal to this face having random orientation; the wire then has a (110) texture.

The (001) planes have been reported as the cleavage planes in body-centered cubic metals such as alpha-iron and tungsten. However, in molybdenum, which is also body-centered cubic, experimental X-ray evidence indicating a similar cleavage plane still seems lacking. Tsien and Chow observed microscopically in the extension at around 1000°C of molybdenum single crystalline wires 0.25 mm in diameter that the fracture plane seemed to be parallel to the operative slip plane, which appeared to be (110) at that temperature. Zapffe pointed out from fractographic study of polycrystalline molybdenum that "although the transgranular pattern is characteristically non-crystallographic, patterns occasionally reveal (100) cleavage." This has been generally assumed to be the case at ordinary temperatures.

Nen-Kuan Chen and Robert Maddin performed experiments on single crystals of molybdenum to make observations on cleavage and polygonization. A single crystal of Fansteel molybdenum, ¼ inch in diameter by 2 inches long, prepared by the methods previously described by Chen, Maddin, and Pond was fractured at room temperature by bending. The fracture surface appeared to be quite similar to the cleavage surface of zinc and was crystallographic A back-reflection Laue photogram was made using 35 kv copper white radiation; the X-ray beam was perpendicular to the cleavage surface. It was concluded that the (100) plane is the plane of cleavage.

An interesting phenomenon apart from the cleavage described above was the polygonization of a single crystal of molybdenum after being bent at around 2400°C. The specimen was ¼ inch in diameter by 6 inches long containing a single crystal in the center section about 1¼ inch long. It was polished electrolytically and then reheated in the modified Andrade furnace to a temperature of about 2400°C in 30 minutes. The specimen expanded freely up to a temperature of about 2200°C as measured by a dilatometer. At a temperature of between 2300°C and 2400°C, the expansion was inhibited in some manner so as to cause a sudden sharp dip in the dilatometer reading. After examination at room temperature, a sharp bend through an angle of 15° was noted in the single crystal.

Slip lines observed at room temperature were broad and well-marked and appeared to be very branched. X-ray photograms taken on three sides of the bent section revealed the orientation of the original crystal. However, the Laue spots were elongated and divided into small individual areas. The break-up of Laue spots in deformed crystals after annealing has been observed in aluminum, sodium, zinc and silicon ferrite. It has been termed polygonization by Orowan and Cahn. They reasoned that an elastically bent lattice could be transformed into strain-free polygons by annealing. Thus the present observation on the polygonization of a bent single crystal of molybdenum at high temperature is comparable to the behavior of other metals.

A stereographic plot of the Laue streaks shows that the rotation of the crystallites is about a (112) axis, which is in the slip plane (110) and 90° from the slip direction (111). This checks with the microscopic observations of slip and also confirms the general type of crystal rotation in the plastic deformation of single crystals.

Commercial Use of Molybdenum

To be sure, there are many practical, industrial uses for molybdenum, the major one being the manufacture of alloy steels. More than three quarters of the molybdenum produced has been used for this purpose, either as molybdic oxide, ferro-molybdenum or calcium molybdate.

Up to a few years ago the physical properties of molybdenum that were studied and measured were those pertaining to lamps and valves. In recent years properties relating to its uses in engineering materials have been investigated, especially the effect of temperature on the strength and ductility, and more particularly, on the creep properties of molybdenum. Until recent years the investigations of molybdenum were invariably made upon sintered or sintered and worked material, but there is now

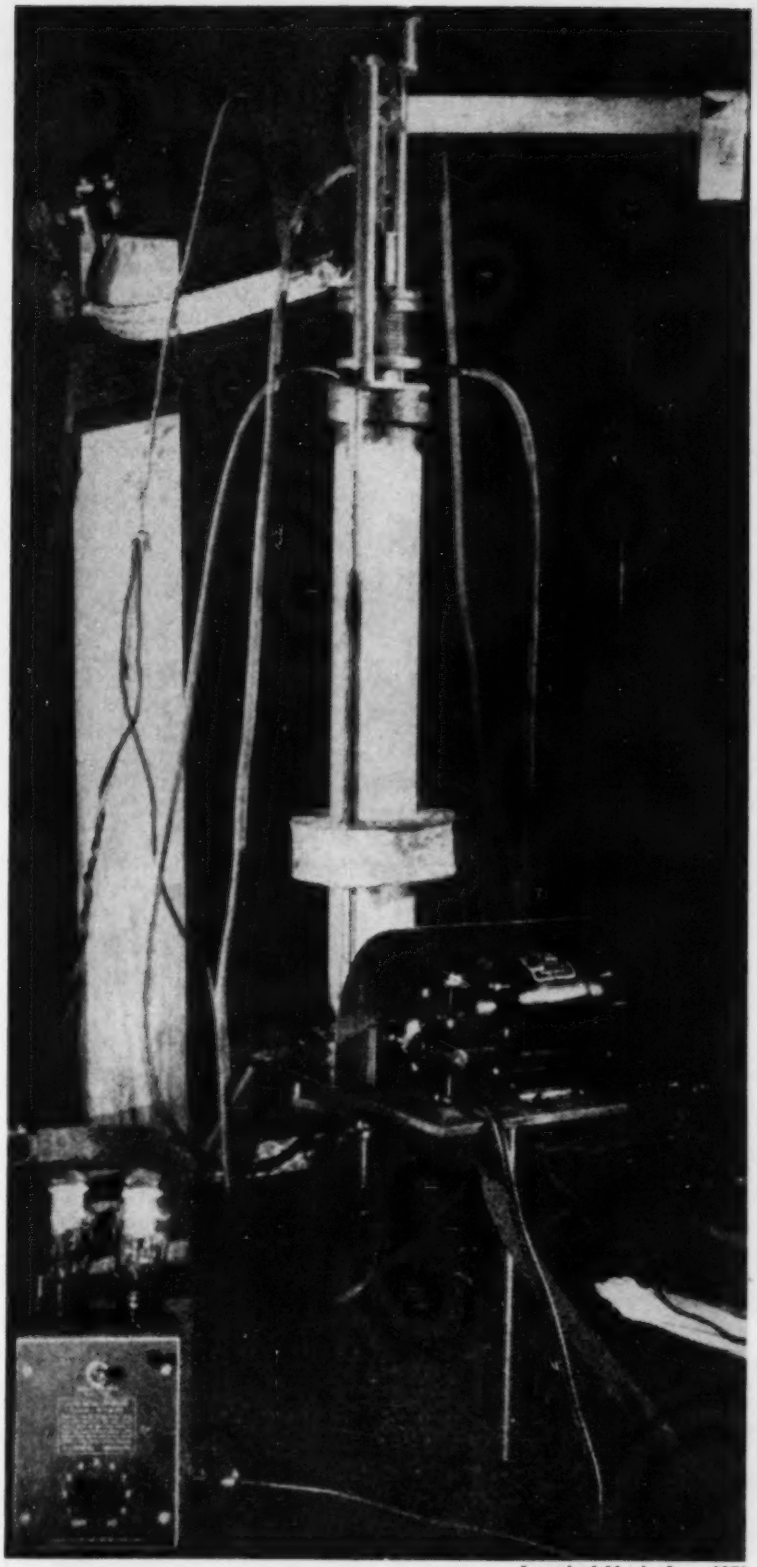
a fair amount of information upon the properties of arc-cast or arc-cast and worked molybdenum.

Before 1939 the most extensive use of metallic molybdenum was in the form of wire and strip in the lamp and radio valve industries. Incandescent lamps have tungsten filaments supported by molybdenum wires or hooks, molybdenum being chosen for this purpose owing to its economy and ease of working as compared with tungsten. Tungsten filaments are coiled on molybdenum mandrels or fine core wires which are dissolved away after the filaments are baked at high temperature. In radio and electronic valves molybdenum anodes are used in sheet or mesh form, sometimes coated with zirconium to act as a getter and increase thermal emissivity. Grids operate at only moderate temperatures but have to withstand high temperatures during manufacture. Other applications are springs for cathodes in discharge valves of various types, distance pieces, plates, discs and anode grids and caps in X-ray tubes.

Molybdenum is an excellent material for glass-metal seals, its average coefficient of expansion is about the same as that of hard glass and a tight seal between glass and molybdenum is possible because molybdenum oxide dissolves readily in glass; alloys of molybdenum and iron with copper possess a coefficient of expansion that can be readily adjusted to that of the glass by changing the molybdenum content. The high electrical conductivity of molybdenum is an advantage in its use as lead-in wires or rods.

A recently developed application is in the form of heavy bars as electrodes for glass-melting furnaces. Not only has molybdenum high strength at elevated temperatures and good electrical conductivity for this purpose, but it is resistant to attack by molten glass and the small amount of oxide formed is colorless.

High temperature furnaces with heating and supporting elements of molybdenum are in wide use where temperatures beyond the limits of ordinary resistance elements are required. Such furnaces



Journal of Metals, June, 1951

A modified anode furnace is used to obtain very rapid grain growth so that single crystals of high melting point metals can be made with ease. High uniform temperatures are maintained by passing an electric current through a thin wire surrounded by an evacuated fused quartz tube. L. C. Tsien and Y. S. Chow prepared single crystals of molybdenum 0.25 mm in diameter with such a furnace.

are common for the hydrogen reduction of oxides in the manufacture of metal powders such as tungsten, molybdenum, cobalt, etc., and for the sintering of carbides, hard metals and high temperature metals. The elements must be protected from oxidation by a reducing or inert atmosphere or vacuum; hydrogen or dissociated ammonia is commonly employed. Molybdenum has long life in this application provided that a non-oxidizing atmosphere is maintained, large element sections are used, hence low voltage heating current, and direct contact between heating elements and furnace lining is avoided. The disadvantage of thin wires is that any reduction in cross section, due to corrosion or oxidation, leads to overheating and early destruction. Furnaces with molybdenum elements can run continuously up to 1700°C and with care up to 2200°C. The high strength of molybdenum at high temperatures permits the use, if required, of unsupported elements in the horizontal position; the high melting point permits high current density due to skin effect thus giving economical heat transmission, current densities up to 80 watts/cm^2 or more being possible.

Now that molybdenum is available in massive form, interest is turning towards possible engineering applications, and use as heavy electrodes in glass-melting furnaces has been mentioned. Its high rigidity and modulus of elasticity show the material to be of value for boring bars leading to a decrease in vibration and an improvement in accuracy and surface finish of the parts being machined. In spite of its higher first cost, encouraging results have been obtained in the use of molybdenum for piercing points for the hot piercing of billets in the production of seamless tubes; its continuous use without cooling or reconditioning has proved economical. The use of molybdenum alloys for hot-working dies and die-casting of the higher melting point commoner metals shows promise. Much development work is proceeding on applications for heat engines. The extensive use of molybdenum as an alloy of steel accounted for it's high production during the war years.

General Properties and Uses

Pure molybdenum is an extremely high strength material. The greatest value of this material is, however, its ability to maintain this strength at extremely high temperatures. This property makes it a valuable alloying metal in increasing the high temperature properties of steel. The outstanding strength properties of molybdenum alloys over a broad temperature range endow them with a currently unique position among the family of structural materials.

The melting point of molybdenum is exceeded only by tungsten and tantalum among the more readily available refractory metals; its modulus of elasticity of about 46×10^6 psi, at room temperature, is among the highest of the commercial structural materials and exhibits a low-temperature dependence; it has high thermal conductivity, low specific heat and low coefficient of thermal expansion and the thermal conductivity decreases only slightly with increasing temperature. Above a temperature of 1600°F, the unalloyed metal itself exhibits superior tensil strength and creep to rupture strength properties than the best of iron, cobalt or nickel base alloys.

Molybdenum has the tendency to lower the critical points which increases the ease of hardening: steels containing molybdenum can be hardened by less drastic quenching than similar steels lacking this element. This ease of hardening is of chief importance in that it decreases the difference in hardness between the core and surface of the quenched steel or, expressed in another way, it is important in decreasing the mass effect.

In all molybdenum steels, with the exception of a few cooled very rapidly, transformations occurred above room temperature. Molybdenum, therefore, differs from manganese and nickel in that no quantity of molybdenum renders austenite stable at room temperatures. This is not at all surprising, for molybdenum not only forms a stable carbide, and probably double carbides, but to decrease the gamma field or, to render alpha iron stable over a greater temperature range.

In general, the critical-point phenomena in molybdenum steels are consistent with the idea that at least a portion of the molybdenum separates in the form of a carbide at low temperatures. At the lowering temperature, considerable quantities of the carbide are apparently dissolved in the austenite matrix.

Another of the benefical high temperature properties of molybdenum is its use in curtailment of the creep rate. Below 700-800°F, creep is small but, above this range, steel will flow continuously under an applied load.

The United States Steel Co. conducted experiments on creep and stress for rupture in 10,000 hours at temperatures greater than 800°F. The results showed how molybdenum increases the stresses for rupture in 10,000 hours and for two given creep rates.

Molybdenum's chief ore is molybdenite. It is a molybdenum disulphide, MoS_2, containing 60% molybdenum, occurring in granite, gneiss, and granular limestone. Molybdenite resembles graphite in appearance, with a lead-gray color, metallic luster, and greasy feel. The American production of molybdenite is from Colorado, New Mexico, and Nevada. Molybdenum ores are converted into ferromolybdenum or into calcium molybdate for use in adding molybdenum to steel. The silvery-white metal is also a by-product of copper ores. About 90% of all molybdenum is produced in the United States, the remainder coming from Chile, Mexico, Peru, and Norway. It is ductile, softer than tungsten and is readily worked or drawn into very fine wire. The coefficient of thermal expansion is low, and the heat conductivity is twice that of iron. The tensile strength of rolled molybdenum is up to 260,000 psi. Because of the high melting point, the extraction of the metal is similar to that of tungsten. The commercial metal is 99.95% pure. It is used for grids, hooks, and support members in radio and light bulbs, for windings in electric furnaces, welding electrodes, and for powder metallurgy. The metal can be made into sheets as thin as 0.001 in., and in wire as fine as 0.004 in. Molybdenum wire is also used in hot-spraying equipment for metallizing

aluminum, magnesium, or bronze to give a hard wearing surface. The hot-sprayed metal bonds firmly to the light-metal alloys. Hydrogen-reduced molybdenum powder is of high purity and fine particle size. Most of the molybdenum used is employed in alloy steels, and for this purpose it is used in the form of ferromolybdenum, which is made directly from the ore by reduction with carbon, lime, and silicon, and adding iron. The standard grade of ferromolybdenum contains 50 to 60% molybdenum with up to 2.5% carbon. It is marketed in steel drums on the basis of the contained molybdenum metal.

Molybdenum in iron is not a carbide-former or a graphitizer. It goes into direct solid solution and refines the matrix, increasing the strength, toughness, and wear resistance. The resulting irons are more uniform in structure than plain cast iron. A plain molybdenum cast iron with 0.65% molybdenum has a tensile strength of 44,000 psi and Brinell hardness 223, which can be raised by heat treatment to above 60,000 psi with Brinell above 300. Greater hardness can be obtained in the iron with the addition of small amounts of chromium. An iron with 0.80% each of molybdenum and nickel, without chromium, has a tensile strength of 50,000 psi and a hardness of 270 Brinell. It has great uniformity, and can be cast in combined thin and heavy sections.

Next to carbon, molybdenum is the most effective hardening element for steel. It also has the property, like tungsten, of giving steel the quality of red-hardness, requiring a smaller amount for the same effect. It is used in hot-work steels, and to replace part of the tungsten in high-speed steels. It is added to heat-resistant irons and steels to make them resistant to deformation at high temperatures and to creep at moderate temperatures. It increases the corrosion resistance of stainless steels at high temperatures. Molybdenum in small amounts also increases the elastic limit of steel, reduces the grain size, strengthens the crystalline structure, and gives deep hardening. It goes into solid solution, but when other elements are present it may form carbides and harden the steel, giving greater wear resistance. It also widens the heat-treating range in tool steels. Because it decreases the temper brittleness of aluminum steels, small amounts are added to nitriding steels. Carbon-molybdenum steels are easier to machine than other steels of equal hardness.

[Ed. Note:] This article was written as a paper in the Materials 1242–1243 course under the direction of Prof. Arthur Ruoff.

BIBLIOGRAPHY

1. Tsien, L. C., and Chow, Y. S., *Guide of Single Crystals of Molybdenum*, Proc. Royal Soc. London (1937) 163A, p 19
2. Chen, N. K., Maddin, R., and Pond, R. B., *Growth of Molybdenum Single Crystal*, Journal of Metals, June 1951, p 461
3. Lu, S. S. and Chang, Y. L. *Proc. phys. Society London* 53 (1941) p 517
4. Tsien, L. C. and Chow, Y. S. *Proc. Royal Society* 163 (1937) p 19
5. Zapffe, C. A., Landgraf, F. K., and Worden, C. O., *Fractographic Study of Cast Molybdenum*, Trans. AIME (1949) 180 p 616

SCIENTIFIC-TECHNICAL BOOKS

REFERENCE BOOKS

HANDBOOKS

Through a cooperative arrangement with publishers, we have established in our bookstore a special section of REFERENCE BOOKS.

We invite you to visit this display, and to examine the books at your leisure. We will, of course, secure any books for you not on display. We receive new books, as published, for inclusion in the display.

TRIANGLE BOOK SHOP

412 College Ave. Phone 2-2304

POP'S

place

RESTAURANT AND SNACK BAR

open daily

7:00 AM — 7:30 P.M.

415 College Avenue

Ithaca, N. Y.

JUST 3 MINUTES FROM THE ENGINEERING QUAD

This steel plant consumes 1/400th of the electric power generated in the United States

Surprising? Not if you realize that steelmaking requires a tremendous amount of electric power.

It takes about 20,000 electric motors to drive the rolling mills and other equipment at our Sparrows Point Plant, near Baltimore, the nation's largest steelmaking plant. Here, at our own steam-electric generating station, we produce enough power for a city of 250,000.

It goes without saying that we need the services of electrical engineers to design, construct, and maintain the vast and complicated array of electrical equipment at our many plants and facilities.

Bethlehem offers excellent career opportunities for men in virtually all engineering curricula: *metallurgical, mechanical, chemical, industrial, civil, mining, ceramic, architectural, and others. We suggest that you discuss Bethlehem with your Placement Officer. And be sure to pick up a copy of our booklet, "Careers with Bethlehem Steel and the Loop Course."*

BETHLEHEM STEEL COMPANY
Bethlehem, Pa.

Steel *for Strength . . . Economy . . . Versatility*

BETHLEHEM STEEL

BETHLEHEM STEEL

When writing to advertisers please mention the CORNELL ENGINEER.

Jobs at Du Pont offer...

Challenge

...important, stimulating work in your chosen field, for a company that's a leader in research—the development of new products, new ways of producing them, and new areas for their use. Du Pont's methods of training, extensive modern equipment and working atmosphere will help you work at the top of your ability, help you keep growing.

Opportunity

...for continuing advancement consistent with your qualifications, working with men who have made their mark, learning from men who have achieved. Here you are given every encouragement to score your own success. Here you are an individual; your own good ideas are wanted, you are credited with them, and you will be rewarded for them.

CHEMISTS **ENGINEERS**

PHYSICISTS

MATHEMATICIANS

due soon to receive a Bachelor's, Master's or Doctor's degree... talk with your placement officer... or with our personnel representative when he is on campus. Or write us. E. I. du Pont de Nemours & Co. (Inc.), Room 2430-11 Nemours Building, Wilmington 98, Delaware.

DU PONT

REG. U. S. PAT. OFF.

Better Things for Better Living... *through Chemistry*

When writing to advertisers please mention the CORNELL ENGINEER.

CORNELL SOCIETY OF ENGINEERS

107 EAST 48TH STREET 1960–61 NEW YORK 17, N. Y.

PAUL O. GUNSALUS ..... *President*
DONALD D. HAUDE ..... *Executive Vice President*
WILLIAM F. GRATZ ..... *Secretary-Treasurer*
F. CRAMPTON FROST ..... *Recording Secretary*
GEORGE F. MUEDEN ..... *Membership Secretary*

Regional Vice Presidents

New England (Boston) Branch
Walter J. Hickey

Chicago Branch
John P. Gnaedinger

Cleveland Branch
Ladimir R. Zeman

Detroit Branch
Fred J. Finkenauer, Jr.

Delaware Valley (Phila.) Branch
James W. Johnstone

St. Louis Branch
Stephan S. Adams, Jr.

HONORARY OFFICERS

President: D. R. Corson, Dean – College of Engineering

Vice Presidents

J. F. McManus, Asst, Dean
College of Engineering

Gordon P. Fisher, Asst. Dean
College of Engineering

N. A. Christensen, Director
School of Civil Engineering

H. J. Loberg, Director
Sibley School of Mechanical Engineering

H. G. Booker, Director
School of Electrical Engineering

C. C. Winding, Director
School of Chemical & Metallurgical Engineering

T. R. Cuykendall, Director
Department of Engineering Physics

W. R. Sears, Director
Graduate School of Aeronautical Engineering

O. C. French, Head
Department of Agricultural Engineering

ENGINEERING SCHOOL REPRESENTATIVES

Graduate School of Aeronautical Engineering
William Littlewood

Chemical & Metallurgical Engineering
Wayne E. Kuhn

Civil Engineering
Daniel M. Lazar

Electrical Engineering
Walter M. Bacon

Engineering Physics
Thomas W. Hopper

Mechanical Engineering
J. Paul Leinroth

Paul O. Gunsalus

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationships between the College and its alumni."

THE PRESIDENT'S LETTER—

October was a month of great activity for the Society—a two-day Executive Committee Meeting in Ithaca and Dinner Meetings in Chicago, New York and Boston. The Boston Meeting was held in conjunction with the Annual Meeting of the A.S.C.E. and attracted members from various parts of the country.

With regard to the meeting in Ithaca it proved to be extremely profitable in a number of ways. First, we had representatives from three of the Regional Chapters present, so considerable time was spent in discussing the problems of programming and financing the Chapter activities to further the overall objectives of the Society.

We were also able to spend several hours with the Dean, Assistant Deans and the School Directors, learning about their programs and problems and at the same time acquainting them with the plans and objectives of the Society.

Among the matters brought up for general discussion were these:

Drafts of a new Constitution and By-laws were presented by Rox Fuller. The proposed changes are designed to reflect the current methods of operation and to insure that we comply with current tax laws relative to charitable organizations. After a few changes in wording the drafts were approved, subject to legal review, and will be submitted to the membership for adoption at the Annual Meeting in May 1961. Prior to that time they will be printed in the Cornell Engineer so that all members will have a chance to review them.

The necessity of securing an adequate number of engineering freshmen each year to support the fine new physical plant and the excellent faculty was stressed. Society members should and are taking an active part in the Secondary School work, but more needs to be done, particularly in making sure that Guidance Directors in the Secondary Schools have a good picture of what Cornell College of Engineering has to offer. While more effort is in order we should be sure that we are working with the established Secondary School Committees and not in competition with them.

Another aspect of the enrollment problem that came in for considerable discussion was the mortality among the freshmen. This is a matter of great concern to both the College and to the Alumni for it is mighty discouraging to recruit and start training embryo engineers only to have them fall by the wayside before the end of the first year.

Still another interesting proposal was submitted by Walter Hardy – that the Society sponsor a Lectureship at Cornell, directed to the Engineering College, but open to the public. This Lectureship would cover important subjects in engineering which are generally not part of the curriculum: professionalism, ethics, human relations, civic and political activity, etc. You will be hearing more about this proposal.

One of the highlights of our Ithaca Meeting was a Reception at the Big Red Barn for the Faculty of the Engineering College and the Ithaca members of the Society. This gave your Committee an opportunity to meet and talk with President Malott and the Administrative Officers of the University, as well as those responsible for the Engineering College Programs. We were very much impressed with the forward-looking programs and the caliber of the staff carrying them out.

Any thoughts or comments on the above?

PAUL O. GUNSALUS

ALUMNI ENGINEERS

Edited by
Rudy Juliano, EP '64

Robert A. Reinhard M.E. '59 has been assigned as sales engineer to the Trane Company sales office in Philadelphia, Pennsylvania.

Reinhard acceded to his position with Trane, a manufacturer of heating and air conditioning equipment, after completing a specialized company training program for graduate engineers.

Philip Gilman a Chem E. alumnus, has been named divisional sales manager in charge of sales to the chemical and paper industries, by the Taylor Instrument Company

Robert A. Reinhard

of Rochester, N.Y. Mr. Gilman has been associated with Taylor since 1946.

The Westinghouse Corporation has announced the appointment of **Dr. Frank Genovese** to its military advanced systems planning group (WASP) in Washington, D.C.

Dr. Genovese received his bachelor's and master's degrees in Physics from Cornell and his doctorate in physics from the University of Michigan.

His fields of specialization include nuclear physics, atomic weapons, phenomenology and effects, aerophysics, and operations research studies of weapons systems.

At WASP, Dr. Genovese and his colleagues will be responsible for conceiving ideas and planning for future weapons and space systems.

Stephen J. Fineman, E.P. 1960, has been awarded a Daniel and Florence Guggenheim Fellowship for study at the Guggenheim Jet Propulsion center, Princeton University, during the academic year 1960–61.

Mr. Fineman is one of 16 of the nation's outstanding young engineers to receive similar awards. The Fellowships carry stipends of from one thousand to two thousand dollars a year and are awarded annually to students of outstanding ability and promise in fields related to the flight sciences. The Jet Propulsion Center at Princeton was founded in 1948 by the Guggenheim Foundation to promote research and provide educational facilities for outstanding graduate students in the fields of jet and rocket propulsion, and space flight technology.

Mr. Fineman came to Cornell from the Bronx School of Science in 1955. During his years at Cornell he was the holder of a New York State Scholarship, a Cornell State Scholarship and a McMullen regional Scholarship.

William Deans, M.E. 1913, a former associate of Thomas A. Edison and a pioneer in circuit breaker design, retired from active service with I.T.C. Circuit Breaker Company of Philadelphia on Dec. 13, 1959.

Mr. Deans was a Vice-President at retirement and had been so since 1956. Prior to this he was the Company's first Vice-President-in-charge of engineering.

Before joining I.T.C. in 1933, Mr. Deans was general manager of Sundho Electric Company of Newark, N.J. Prior to this he was a member of T. A. Edison's personal staff, and earlier on the staff of Cornell University.

Mr. Dean's significant contributions to the electrical industry center primarily in the area of electrical busses and buss structures used to carry high power at high voltages. He also contributed substantially in the field of circuit breakers, having pioneered in the mathematical treatment of the subject.

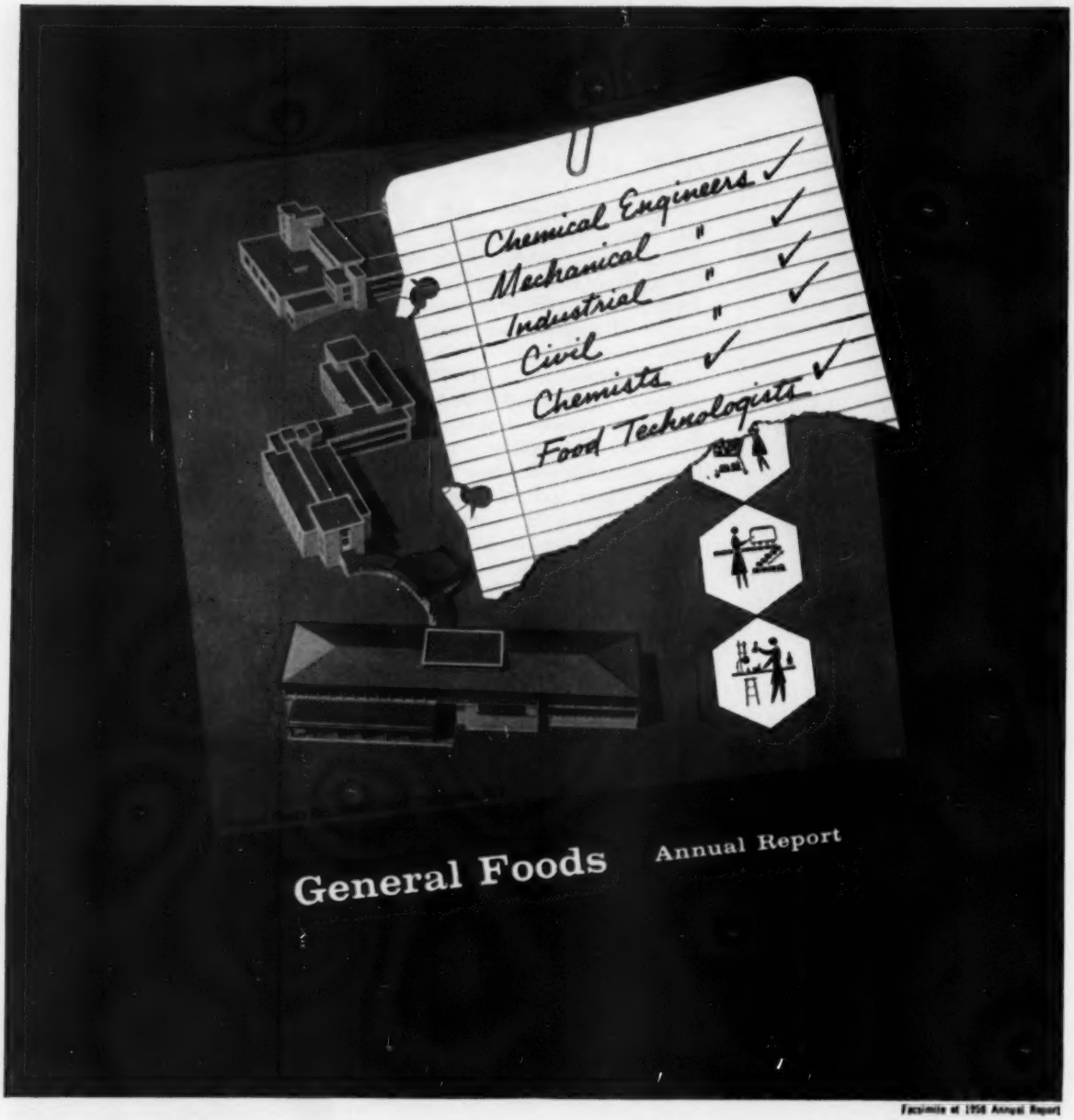
A member of Tau Beta Pi and Eta Kappa Nu, Mr. Deans is also a Fellow of the American Institute of Electrical Engineers, and has been active in the National Electrical Manufacturers Association.

Coleman B. Moore M.E. '24 and president of Moore Products Co. of Philadelphia was named a Fellow of the Instrument Society of America, during the Society's 15th annual meeting in Philadelphia. The honor was conferred upon Mr. Moore for his "distinguished contributions in the field of pneumatics for measurement, transmission, and control".

Before establishing his present company with the purpose of developing and exploring the field of pneumatic circuits, Mr. Moore engaged in foundry, locomotive, automotive, power plant and turbine engineering both in this country and in Europe.

Mr. Moore is the holder of some 75 patents, he has published numerous technical papers, and has given approximately 65 lectures before various technical groups.

Stephen J. Fineman



Facsimile of 1956 Annual Report

Have you considered General Foods?

The food industry is the world's largest enterprise. And, as the largest U.S. packaged food processor in this enterprise, General Foods' continued growth depends on developing and producing new foods.

The accomplishment of these growth plans requires a growing staff of competent engineers, chemists and food technologists.

It may be to our mutual advantage for you to see our representative when he is at your school. Your Placement Director will help you to arrange a meeting. In the meantime, we have two booklets, one on careers in Engineering and one on Research—written for the man coming out of school. Write us for a complimentary copy.

GENERAL FOODS makers of a number of well known food products such as
Maxwell House Coffee • Jell-O Desserts • Post Cereals • Birds Eye Frozen Foods

GENERAL FOODS
COLLEGE RELATIONS
250 North St. • White Plains, New York

Please send me your booklet on careers in:

☐ Engineering
☐ Research

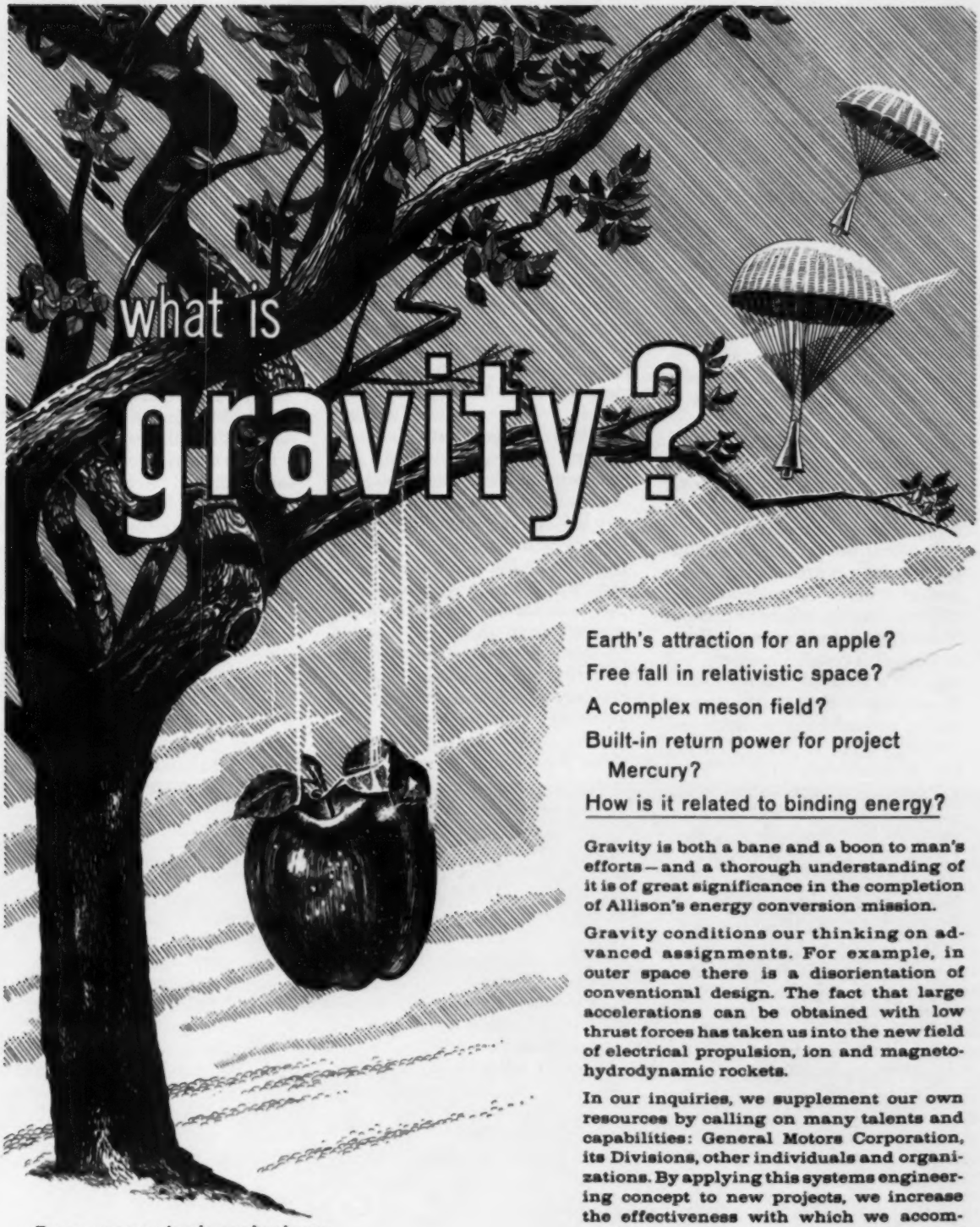
NAME_____

ADDRESS_____

CITY_____ STATE_____

SCHOOL_____

When writing to advertisers please mention the CORNELL ENGINEER.



Earth's attraction for an apple?
Free fall in relativistic space?
A complex meson field?
Built-in return power for project Mercury?
How is it related to binding energy?

Gravity is both a bane and a boon to man's efforts—and a thorough understanding of it is of great significance in the completion of Allison's energy conversion mission.

Gravity conditions our thinking on advanced assignments. For example, in outer space there is a disorientation of conventional design. The fact that large accelerations can be obtained with low thrust forces has taken us into the new field of electrical propulsion, ion and magneto-hydrodynamic rockets.

In our inquiries, we supplement our own resources by calling on many talents and capabilities: General Motors Corporation, its Divisions, other individuals and organizations. By applying this systems engineering concept to new projects, we increase the effectiveness with which we accomplish our mission—exploring the needs of advanced propulsion and weapons systems.

Energy conversion is our business

ALLISON

Division of General Motors, Indianapolis 6, Indiana

When writing to advertisers please mention the CORNELL ENGINEER.

COLLEGE NEWS

Edited by John Hughes, EP '64

NEW BUILDING WILL HOUSE CORNELL MATERIALS CENTER

The Advanced Research Projects Agency, Department of Defense, has announced that Cornell University, University of Pennsylvania, and Northwestern University have been selected to set up vastly enlarged programs for the expansion of basic research in the science of materials.

Under an unprecedented long-term contract Cornell will receive $6.1 million for the first four years of this program, according to Cornell President Deane W. Malott.

The contract provides for interdisciplinary research and graduate student training in materials and will combine the efforts of portions of five departments in two colleges at Cornell. Cornell University will organize a Materials Science Center to administer the ARPA contract and to expand basic research and training of Ph. D. research scientists in materials.

"Materials science" is the investigation of physical and chemical processes in solids such as metals. The design of new materials for nuclear reactors, rocket engines, transistors, and other modern devices is based on this kind of research.

Cornell will construct a new $4 million building on its campus within the next three years. The building will house graduate research of the Laboratory of Atomic and Solid State Physics, the administrative offices of the Center, and several of the common technical facilities such as electron microscopes. ARPA will reimburse Cornell for construction costs of this building over a 10-year period after it is occupied.

Cornell may build a substantially larger building of which the ARPA construction would be a part, to house in addition a physics and chemistry library and some of the other activities of the Department of Physics.

The four-year headway of the ARPA-Cornell pact will be maintained—the fifth year's financial support to be discussed next fall, and further support annually.

A substantial part of the $6.1 million contract will go into research equipment, including about $700,000 for individual research projects and $1.2 million for common facilities. The facilities will permit Cornell graduate students and staff to work with the most modern physical, chemical, and metallurgical techniques available.

Initially, the work of the Laboratory of Atomic and Solid State Physics will comprise the largest part of the Center. This Laboratory, which was organized a year ago, includes faculty and graduate students from the department of physics and the department of engineering physics. Later, the greater growth of metallurgical engineering and engineering mechanics and materials will make these departments equally important.

Cornell was one of the first universities to enter solid state physics, which generally was not recognized as a distinct science until after World War II. Substantial parts of the work at Cornell are concerned with imperfections, transport processes, magnetic resonances, internal friction, photo-chemical processes, surface phenomena, ferroelectrics, magnetic phenomena in dilute alloys, optical processes in the far ultraviolet, x-rays, cooperative phenomena, ferromagnetism, many-particle theory, and thermal conductivity.

The unit of the Center's administration responsible for the long-range program will be the Executive Committee. It will be composed of physical and engineering researchers, each representing one of the fields of Center activity. Sanford S. Atwood, provost of the University, will serve as chairman, and Dale R. Corson, dean of the College of Engineering, Francis E. Mineka, dean of the College of Arts and Sciences, John W. Hastie, coordinator of research, and Paul J. Leurgans, director of the Center, will be members of this Committee.

CORNELL NUCLEAR REACTOR RAPIDLY NEARING COMPLETION

A Nuclear Reactor Facility which will provide training for many of America's potential atomic scientists and engineers is taking shape on the Cornell campus.

Construction crews behind Upson Hall are working day and night on the building which will house two reactors that can be used for both research and training. The unit will have a "zero power" reactor for research, obtained under a grant of $475,000 from the National Science Foundation, and a training reactor called TRIGA (Training Research Isotope General Atomic) toward which the United States Atomic Energy Commission has made a grant of $150,000. TRIGA will also be used in studies involving radioactive isotopes. Total cost of the center will be $1,660,000.

The Facility was designed and engineered by Vitro Engineering Company in cooperation with Cornell scientists and engineers and is expected to be ready for operation next June. General Atomic has the contract for construction of the TRIGA reactor and Curtiss-Wright for the zero power reactor.

The zero power reactor will be used for studying the basic mechanisms by which a self-sustaining reaction may be produced and utilized, and for examining the interaction between neutrons and their surroundings. Scientists and engineers will be able to learn more how neutrons behave under a variety of conditions. Because it will be a modified critical assembly, the device will have a flexible design for studying reactors themselves. It will be the only university-owned reactor in the country to possess this flexibility.

The TRIGA training reactor will enable Cornell's science and engineering students to gain first-hand experience in the study of nuclear processes. It will also be used in research programs at the University.

The Facility will be under the direction of Professor Trevor R. Cuykendall and Associate Professor David D. Clark of the department of engineering physics at Cornell.

POWERFUL TRANSMITTER TO BE BUILT FOR GIANT ANTENNA

Levinthal Electronic Products has received a $580,000 subcontract from Cornell University to build an unusually powerful transmitter for the radar installation at Arecibo, Puerto Rico. The 1000-foot dish-shaped antenna, which can also be used as a radio telescope, will be by far, the largest installation of its kind in the world, capable of picking up an object one cubic yard in size at a distance of 20,000 miles.

The giant Levinthal transmitter connected to this dish has impressive dimensions and capabilities. It will take an area, approximately 41 ft. wide by 60 ft. long by 25 ft. high to house the one transmitter. The advanced instrument will produce 2½ megawatts of peak power and 150 kilowatts average power at approximately 430 megacycles.

The immense radar antenna, sculptured out of a natural valley, is built as part of America's space research programs. It will be used to study the characteristics and behavior of matter between the earth and the planets and to receive radar signals from the Moon, Venus and possibly the outer planets.

Another part of the newly-formed Cornell Space Center has been a series of lectures on cosmology given last spring by Professor Gold, director of the Space Center, and several of his former colleagues from Cambridge. Professor Hoyle, another of the "Cambridge Group" of astronomers, was at Cornell last month for a series of lectures relating to the planets, the sun, and galaxies.

EXPEDITION UNCOVERS NEW ARCHEOLOGICAL REMAINS

The remains of buildings destroyed by "sons of Hercules" around 1200 B.C. and others destroyed about 600 years later by the king of Persia are among major discoveries made this season by the Cornell-Harvard expedition to Sardis, Turkey, once the Paris of the ancient world.

The directors of the expedition, Prof. George M. A. Hanfmann of Harvard and Prof. A. Henry Detweiler of Cornell, reported that, by following the changing style of pottery fragments of Greek origin, the expedition had pinned down in time a sequence of settlement from 1250 to 700 B.C. The evidence affords a new insight into the transition from the Bronze Age to the Iron Age in Western Asia Minor.

The expedition's discoveries, which span 2700 years of the city's

This is an artist's representation of Cornell's new radio telescope, to be used in probing the mysteries of the universe.
Courtesy University News Bureau

Proud of your School?

BE PROUD OF YOUR WORKING TOOLS...

A.W.FABER
CASTELL
helps the hand that shapes the future

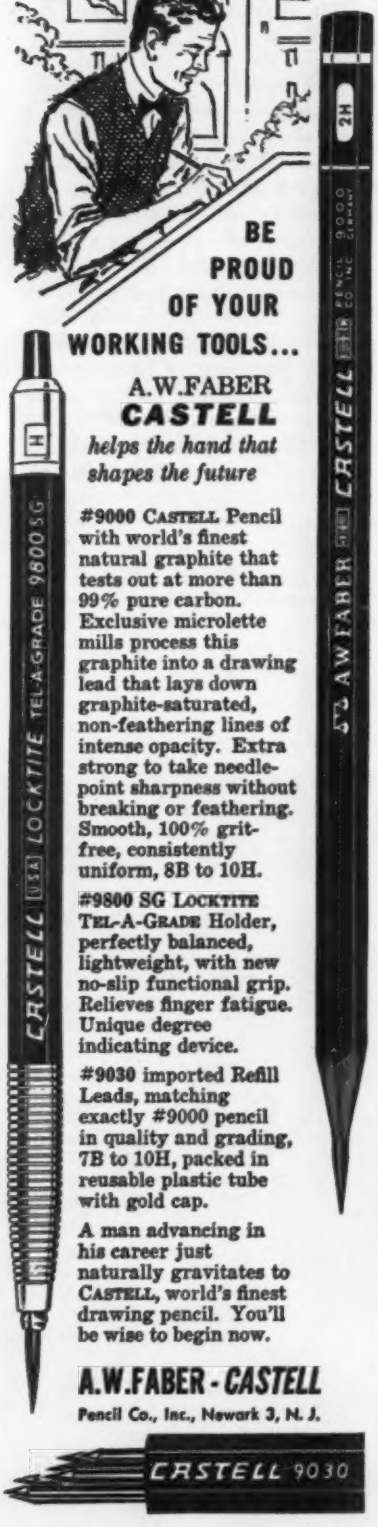
#9000 CASTELL Pencil with world's finest natural graphite that tests out at more than 99% pure carbon. Exclusive microlette mills process this graphite into a drawing lead that lays down graphite-saturated, non-feathering lines of intense opacity. Extra strong to take needle-point sharpness without breaking or feathering. Smooth, 100% grit-free, consistently uniform, 8B to 10H.

#9800 SG LOCKTITE TEL-A-GRADE Holder, perfectly balanced, lightweight, with new no-slip functional grip. Relieves finger fatigue. Unique degree indicating device.

#9030 imported Refill Leads, matching exactly #9000 pencil in quality and grading, 7B to 10H, packed in reusable plastic tube with gold cap.

A man advancing in his career just naturally gravitates to CASTELL, world's finest drawing pencil. You'll be wise to begin now.

A.W.FABER - CASTELL
Pencil Co., Inc., Newark 3, N. J.



history, were made by a team of 17 scholars and students, aided by nearly 200 workmen.

On the citadel high above the ancient city of Sardis, Donald P. Hansen of Hastings-on-Hudson, N.Y., found remains from the time of the Persian conquests. In complex and often dangerous digging under tons of loose earth and over precipices, he found fragments of an exquisite cup imported from Athens and illustrating an heroic battle and the legendary hunt of the Calydonian boar. Inscribed "Hail and Drink Well," the cup may have belonged to one of the Lydian captains who made their last stand on the citadel against the Persian onslaught. Some of the Persian arrow heads used in the assault also were found. In a Byzantine well, Mr. Hansen also uncovered part of a sixth century marble throne portraying a lion. It was probably the seat of an image of the goddess Cybele, the great protectress of Sardis.

Among the other results of the most successful summer at Sardis was the discovery of fragmentary Byzantine wall paintings in a large bath. Important finds of glass were studied by Axel von Saldern of the Corning Glass Museum.

The excavations at Sardis are sponsored by Cornell University, the Fogg Museum of Harvard, the American Schools of Oriental Research and the Bollingen Foundation of New York.

CONVECTION PROCESSES STUDIED BY PROFESSOR

While searching for methods of cooling re-entry vehicles, a Cornell University mechanical engineer and a colleague discovered that heat transfer by natural convection may be stopped by spin.

As a result of the find made in connection with an Avco Corporation research program aimed at cooling space vehicles during re-entry through the earth's atmosphere at tremendous speeds, the National Science Foundation has made a grant of $72,100 so that Professor David Dropkin can continue to direct the research.

The grant was made on the basis of work performed under Professor Dropkin, a member of the Department of Thermal Engineering, School of Mechanical Engineering, Cornell, and Samuel Globe, Avco physicist. It enables Professor Dropkin to continue the research aimed at compiling additional data and information.

Using cylindrical containers of various sizes, some as small as 1.39 inches high and 5.28 inches in diameter, Professor Dropkin's research team is simulating conditions inside a space vehicle. The containers consist of chromium-plated copper plates one-fourth of an inch thick, top and bottom, and pyrex glass sides.

Their work seeks to improve the understanding of the natural convection process in confined fluids and to gain additional heat transfer design data.

With data being gathered and comparison of information concerning various liquids, Professor Dropkin's research team at Cornell hopes to create a formula that will enable space scientists to compute beforehand the amount of heat that will be transferred for a given rate of spin. The work also concerns other equipment where heat transfer is a factor.

Professor Dropkin and physicist Globe in a paper published in the Journal of Applied Physics demonstrated that above a defined point the presence of spin about a vertical axis reduced the heat transfer by natural convection in mercury and other liquids.

Their data indicates that it is possible to stop the heat transfer by convection when the proper spin, height of liquid in the container, and liquid flow motion are attained. At this point the reduction of heat transfer begins and the convection is completely stopped.

Professor Dropkin is currently a consultant to the Avco Company on heat transfer problems, and in 1957, while on leave from Cornell, was a senior scientist at Avco Research and Advanced Development Division. In 1949–50 he was a visiting engineer at Brookhaven National Laboratory and remained in charge of projects on heat transfer in liquid metals until 1956.

NORTHROP

Northrop is an analog for progress where engineers – and ideas – grow to reach their maximum potential. It takes a lot of engineer to measure up to Northrop's creative engineering challenges.

To convert our sophisticated requirements into producible and reliable systems calls for intellectual stature, disciplined imagination, and an explorer's venturesome curiosity.

Northrop is rich in advanced projects to grow on. If you want to associate yourself with an organization that is producing tomorrow's technological headlines today, stand up and be measured. Send us a card or letter today with your name, address, and area of special interest.

NORTHROP CORPORATION, P.O. BOX 1525, BEVERLY HILLS, CALIF.

DIVISIONS: NORAIR / RADIOPLANE / NORTRONICS

When writing to advertisers please mention the CORNELL ENGINEER.

2 minutes after start of system under test. Note how fire-extinguishing foam blankets potential fire area.

This test shows how Grinnell's Spray-Foam System protects hazardous fire areas

In the dramatic illustration shown above, you see a Grinnell Spray-Foam System under test at a truck loading terminal in Detroit, Michigan. This fire-quenching foam system, designed for hazardous areas, is especially recommended for quelling blazes in petroleum base products, such as in gasoline, kerosene and fuel oil. Grinnell Systems are effective in controlling fires in chemicals, alcohols, benzol, solvents, paints and liquid gas.

Grinnell has had 89 years of experience in fire protection work. You benefit from this vast amount of specialized fire knowledge whenever you call on Grinnell. For information, write or phone Grinnell Company, 277 West Exchange Street, Providence 1, Rhode Island.

Grinnell Fire Protection Systems include:

- Automatic Spray Sprinkler Systems: wet pipe, dry pipe, deluge and Simplex*
- Water Spray Systems with regular or Selfcon* (self-contained) water supplies; Multitrol* or Multimatic* valve; ProtectoSpray* nozzles or Mulsifyre* projectors
- ProtectoFoam* systems, producing mechanical foam
- Carbon dioxide systems
- Dry chemical systems

*Reg. U. S. Pat. Off.

GRINNELL FIRE PROTECTION SYSTEMS SINCE 1870

ENGINEERING GRADUATES HAVE FOUND ATTRACTIVE OPPORTUNITIES WITH GRINNELL

When writing to advertisers please mention the CORNELL ENGINEER.

Advanced power conversion systems for space vehicles utilizing energy of the sun or heat from a nuclear reactor are now being developed by Garrett's AiResearch divisions. Under evaluation are dynamic and static systems which convert heat into a continuous electrical power supply for space flight missions of extended duration. Component and material developments for these systems are being advanced in the fields of liquid metals, heat transfer, nonmechanical and turboelectric energy conversion, turbomachinery, alternators and controls.

Besides solar and nuclear power systems for space applications, other product areas at Garrett include small gas turbine engines, environmental systems for advanced flight vehicles, cryogenic fluid systems and controls, pneumatic valves and controls and missile accessory power units.

This diversification of project areas enables the engineer at Garrett to specialize or diversify according to his interest, not only making work more interesting but increasing the opportunities for responsibility and advancement.

An orientation program lasting several months is available for the newly graduated engineer, working on assignments with highly experienced engineers in laboratory, preliminary design and development projects. In this way his most profitable areas of interest can be found.

For further information about a career with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

When writing to advertisers please mention the CORNELL ENGINEER.

TECHNIBRIEFS

Edited by Richard Epstein, EE '62

PHOTOGRAPHY: KEY IN NEW TRANSLATING MACHINE

Photography, the recording medium that stores the greatest amount of information in the smallest space, is the key to success of the Air Force's new translating machine that changes Russian to English at the rate of 40 words per minute.

Previous translating machines have usually been modified computers. Their Russian-English "vocabularies" were stored on magnetic tape or punched cards. This limited both the size of the vocabulary that could be stored and the speed with which it could be searched electronically for words and phrases.

Through photography, an entire 55,000 word vocabulary is stored in a ¾-inch channel printed on a ten-inch glass disk. The channel is scanned vertically and horizontally by electronics until the machine matches a Russian word—fed in with punched tape—to its English equivalent, which is then printed automatically on a typewriter.

Modifications of the machine will enable it to translate more than 2,400 Russian words per minute with greater precision and better grammar than it does now at the slower rate. At present the English translation emerges in a rough but meaningful form for refinement by human translators.

When more of the capacity of the photographic disk is used, it will store about 500,000 Russian words and idioms on a single surface. Words are printed in a line code of bars and spaces.

Even with a 500,000 word vocabulary the disk barely scratches the surface of photography's information storage capacity.

A Kodak research scientist recently disclosed that a high-resolution film, exposed with present optics, is capable of storing 600 million bits of information per square inch. This means that the entire contents of the Encyclopedia Britannica could be stored on a single 4-inch square piece of film.

ELECTRONIC BODY MEASURES HEIGHT OF SEA SWELLS

Accurate, reliable reports of surface conditions at sea during hurricanes will soon be available as a result of the development of an unmanned "transobuoy" by the Navy. The free-floating miniature weather stations will for the first time provide direct reports of the height of waves, along with other meteorological information such as air and ocean temperature, barometric pressure and the velocity and direction of the wind.

Wave height information will be collected and reported by a new sensing device developed for the Navy by the Advanced Undersea Warfare Engineering unit of the General Electric Advanced Electronics Center at Cornell University, the R&D facility of GE's Light Military Electronics Department, headquartered at Utica, N.Y.

The free-floating, battery-powered transobuoy will bob about in the traditional spawning area of the powerful hurricanes. It will be interrogated by radio for two and a half minutes every half hour. Its location will be determined by radio direction finder fix.

It will be the first time that waves will be measured simultaneously with other meteorological data in hurricane generating areas. The combination should improve forecasting substantially. Accurate wave height information can be invaluable to ship operators. A cargo ship which has a normal cruising speed of 16 knots in five foot waves must reduce speed to six knots when waves reach 25 feet. By rerouting ships around the stormy areas, crossing times can be cut by as much as ten per cent.

General Motors

Electro Lane, a devise to warn motorists when they are too close to pavement edge or centerline, is undergoing full-scale tests at General Motors Proving Ground.

As a result of the development of the Sea/Swell Sensor, for the first time in history weathermen and oceanographers will be able to get consistent, scientifically reliable reports of the height of the biggest waves whipped up by hurricanes at sea. According to Dr. Francis E. Elliott, GE oceanographer in Ithaca, most of the first-hand reports are exaggerated. "Those in a position to observe wave height in a hurricane are usually too busy surviving to make accurate measurements," Dr. Elliott says. "Not only that, but there is a psychological factor which apparently distorts the actual size of the waves in the mind of the observer. We have many reports from sailors which indicate 100 foot waves. However, so far there are no really reliable scientifically accurate reports of waves higher than about fifty feet."

The transobuoy will help reduce the time, cost and risk of carrying weather observers to storm areas at sea. "Of course," says Dr. Elliott, "nothing yet built will provide the speed, mobility and completeness of shipborne and airborne human observers. But the transobuoy is a real step forward in weather science."

"COCKTAIL PARTY" EFFECT REPRODUCED ELECTRONICALLY

The psychoacoustic phenomenon called the "Cocktail Party Effect" has recently been duplicated electronically by a group of investigators at Bell Telephone Laboratories. This term has been applied to the ability of the human listener to concentrate on a specific voice in which he is interested, and thereby separate it from the surrounding babble of voices or other noise, even though it may be no louder than the surrounding noise level.

The binaural, or two-eared, listener is able to enhance the effective intensity of the desired voice by 5 to 15 decibels by suppressing the background noise level. A scheme for reproducing

this feat electronically was recently described by E. E. David, Jr. and J. F. Kaiser of Bell Laboratories to the Acoustical Society of America, meeting in Providence, R.I.

In the cocktail party effect, the sound-waves picked up by the two ears are used. The single ear, with only one sample of the sound field, cannot pick out specific voices or sounds from a surrounding babble as easily. A telephone transmitter, or any single microphone, is similarly unable to suppress spurious noises. Thus, background noise interferes much more with the voice of a person talking over a telephone or loudspeaker system than the same noise would if the two-eared listener were standing in the same room as the talker.

Non-linear techniques were used in the attempts to duplicate the effect electronically. In one technique, the outputs of two microphones were compared, or cross-correlated, to generate a "gating wave" which was then applied to the combined output of the two microphones. The effect of this gating was to raise the intensity of the combined signal only when energy from the desired voice arrived simultaneously at both microphones. Otherwise, the gate suppressed the combined signal. Noise or interfering speech signals passed through the gate if they occurred simultaneously with the desired speech signal. However, these events were rare and the pattern, or continuity, of the undesired signal was disrupted. Thus its interfering qualities were greatly reduced.

SILICONE RELEASE IMPROVES PAPER PRODUCTS

A study of silicone release coatings for the paper industry made by the General Electric Company has thrown new light on why silicones give outstanding release properties.

De Monterey, a GE chemist, described two distinct kinds of release action. The first, which he termed "hydrodynamic" release, is due to a thin low-order multimolecular layer of silicone oil, which is interposed between the substrate and the tacky material. This layer, he said, has such low cohesional energy that release is due to absence of any bonding or other interaction between silicone and adhesive, or silicone molecules between themselves.

A second kind of release action, found in the more recent silicone release materials, forms solid thin films when cured on paper substrates. Release from such a film, he noted, shows no oiliness on the surface and is a phenomenon of a more complex nature.

"We have considered intra-and-inter molecular forces between various 'modules' of silicone polymers", de Monterey explains, "arriving at the tentative conclusion that release is largely due to resilience of a more or less orderly built-up layer of long chain methyl polysiloxane macropolymer. In this layer, a large assembly of macromolecules are interlocked physically as well as chemically by reactive crosslinks".

De Monterey terms these "bedspring" molecules, which turn low-energy methyl groups to any surface while restoring forces of laterally or longitudinally-compressed molecular groups tend to add to release. His conclusion is that these molecules actually mechanically repel adhesive substances with a spring-like action.

The immediate interest in the paper industry stems from the need for a release material which permits the manufacture of paper and paperboard products capable of releasing such materials as asphalt, latex, adhesives, etc. Silicone release agents are now available which, when coated on cartons used for packaging asphalt and other adhesive materials, allow the carton to be peeled off without tearing or adhering to any noticeable extent. The result has been a considerable savings of time and effort throughout the industry.

ELECTRO LANE WARNS WANDERING DRIVERS

An experimental device that visably or audibly warns a motorist when he's too close to the pavement edge or centerline, will be put to practical use at the General Motors Proving Grounds.

Somewhat comparable to the "beam" by which aircraft pilots keep course from one airport to another, Electro Lane was developed by Electronics and Instrumentation Department of GM Research Laboratories.

When a car veers to the left or right, ferrite core coils on either side of the front bumper pick up electrical signals from the road. Signal strength varies with the pickup coil's distance from the road wire. From an individual coil the 2 kc signal is amplified and fed to one of two warning lights.

Intensity of the light is proportional to deviation toward that side. In addition, the signal from either side or pickup coil is applied to a network that feeds a speaker only after a pre-set level is reached. Thus, a driver will be alerted by light or sound, or both, if he is too far toward the right pavement edge or toward the left roadway centerline.

Holley Carburator Co.

The electronic Analog Simulator and operator training consoles for the Enrico Fermi atomic plant near Monroe, Michigan. The simulator is an electronic working model of the fast-breeder reactor.

CRESCENT

Insulated Wires and Cables

Pictured here are just a few of the many wires and cables made by CRESCENT. They have an enviable reputation for quality and endurance.

CRESCENT INSULATED WIRE & CABLE CO.
TRENTON, N. J.

C. Edward Murray, Jr. '14

"ONE OF THE GREAT CLOTHING STORES OF THE STATE"

• • •

The store to shop for authentic Ivy clothing and furnishings

• • •

Home of Famous Name Brands

• • •

The SPORT SHOP
CLOTHING FURNISHINGS

One of Ithaca's nicest eating places . . .

The COLLEGE SPA
216 EAST STATE STREET

Your host,
Pete Atsedes

When writing to advertisers please mention the CORNELL ENGINEER.

Record-breaking Atlas missile billows flame and vapor as she launches satellite into orbit.

130 tons of missile with a skin thinner than a window pane!

The Nickel Stainless Steel skin of the Atlas missile is actually about one-third as thick as the glass in your window.

And yet look what this skin does:

• It is the sole structural framework for Atlas—130 tons of dead weight at the moment of firing.

• It serves as the wall of the propellant tanks in Atlas' weight-saving design.

• It withstands the deep chill of liquid oxygen (—297°F) . . . the high heat of supersonic speed (400°F-600°F).

. . . and it is less than 1/25 of an inch thick!

No wonder they call stainless the space-age metal. No wonder engineers turn more and more to Nickel Stainless Steel as temperatures rise . . . as speeds soar . . . as demands get more and more severe.

But space is only *one* of the new worlds science is penetrating, and not even the newest. Witness man's 35,805-foot dive into the depths of the Marianas Trench in the Pacific. Or his exploration of deep cold. Of super pressures. Of ultrasonics.

Before the manipulation of such new environments can even be considered, scientists and engineers need to know exactly what happens to metals under extreme conditions.

Inco Research a source of such data

Quite often, Inco Research has already developed the information needed and has it neatly filed and cross indexed. Ready for use. In several instances, when a new alloy was needed, barrier breakers have found it already developed and tested by Inco Research.

Remember Inco Research when, in the future, you encounter severe new conditions and need useful data.

The International Nickel Company, Inc.
New York 5, N. Y.

INCO International Nickel

The International Nickel Company, Inc., is the U.S. affiliate of the International Nickel Company of Canada, Limited. (Inco-Canada)—producer of Inco Nickel, Copper, Cobalt, Iron Ore, Tellurium, Selenium, Sulfur and Platinum, Palladium and Other Precious Metals.

When writing to advertisers please mention the CORNELL ENGINEER.

FIFTY YEARS AGO IN THE ENGINEER

Edited by R. N. Karnes CE '62

NEW AERIAL MOTOR

A new aerial motor has been developed, according to *The American Marine Engineer*. The motor is a V-type, 8-cylinder, 4 cycle, having L-type cylinders cast in pairs. The hollow crankshaft is made of Krupp's best nickel steel. Cast iron valves are used which are fused on steel stems. Aerial metal, which is stronger and lighter than aluminum, is used for water jackets, pipes and gear housings. The splash oiling system is used with force feed oiler to crank case. These motors are built in two sizes. The smaller has a 3¾ inch stroke and 3¾ inch bore and develops 45 H.P. at 1,800 revolutions, 1,200 revolutions at 34 H.P., and equipped ready to run weighs less than 210 pounds (sic). This motor sells at $1,750. The larger motor has 4-inch bore and 4½-inch stroke and will develop 70 H.P. at 1,800 revolutions, and 56 H.P. at 1,200 revolutions. Equipped ready to run, it will weigh less than 240 pounds. This motor sells for $2,500. *The Sibley Engineer, November 1910*

NEW SUBWAY

The latest proposal for new subway lines is by President McAdoo of the Hudson and Manhattan Railroad Company for the construction of a terminal extending from Broadway and Thirty-third Street, one block from the new Pennsylvania Terminal, southward along Broadway to Union Square, and thence under University Place and Church Street to the Hudson Terminal station at Cortland Street. *The Sibley Engineer, November 1910*

SUNSPOT THEORY

Professor Marcel D'Orey, of L'Institute du Radiodiffusion Francaise, has just formulated a rather incredulous, but highly plausible, theory of the heretofore unexplainable phenomenon of sunspots. According to D'Orey, sunspots are caused by huge electromagnetic disturbances, much as a sudden surge of excess power through an electric motor produces intense heat and sparking. D'Orey in fact says that sunspots themselves are nothing more than huge arcs caused by quasi-periodic imbalance in the sun's energy. He says the reason that sunspots appear dark is that the giant arcs have a subtractive effect upon the light normally emitted from the sun. D'Orey also speculated that the sun may develop its energy through interaction of hydrogen and helium, and that any excess in this interaction is responsible for the quasi-periodic imbalance which causes the sunspots. *The Sibley Engineer, November 1910*

MONORAIL REBUILT

The monorail car, running between Bartow and City Island, New York, which met with an accident on the first day of its operation three months ago, has been rebuilt, and the road, which has been carrying passengers experimentally for some weeks, hopes shortly to commence regular service under a new franchise. *The Sibley Engineer, November 1910*

NEW PEN DEVELOPED

Die Papier-Geschreiben Co., division of *Dreistaaten Bleistift* of Neuenkirchen, Germany, has developed a new pen for use where most ordinary pens fail to write. The new pen is designed especially for use in plants whose atmosphere becomes saturated with water vapor, such as steam-generating plants. It utilizes a round, floating nib instead of the usual pen point, and so is able to write on damp surfaces. However, it is highly questionable whether this pen will ever receive any degree of acceptance by the public. *The Sibley Journal, November 1910*

CURIOUS PHYSICAL PHENOMENON DISCOVERED ACCIDENTALLY BY WILHELMSSOHN

Professor Emil Wilhelmssohn of the Department of Physics at the University has accidentally discovered a curious phenomenon. He was tinkering with a glass incandescent lamp shell and a rubber squeeze bulb, and found that when he put the two together with a bit of water inside, and held the assembly near a piece of pitchblende, tiny vapor trails would traverse the inside of the shell when the rubber bulb is squeezed. Wilhelmssohn is now trying to work up an explanation for the phenomenon. *The Sibley Journal, November 1910*

PhD, MS, BS in EE
PhD, MS in Physics and Mathematics
—would you rather blaze trails in electronic communications theory or consolidate territory newly won?

YOU CAN AIM YOUR CAREER IN *EITHER* DIRECTION AT *STROMBERG-CARLSON*

Division of General Dynamics

***...where** a group of outstanding scientists and engineers are conducting both theoretical and applied studies in many aspects of the science of communications*

While our broad concern at Stromberg-Carlson is in the acquisition, transmission, processing, storage and display of communications data, ancilliary investigations – often seemingly remote – are carried on to enhance our basic understanding of the communications field.

TO THE ADVANCED DEGREE CANDIDATE this frequently offers the opportunity, upon completion of his studies, to continue theoretical investigations initiated in thesis preparation.

TO THE MAN WHO HAS RECENTLY RECEIVED HIS BS, it provides varied career choices: to work directly with experts on research projects; to participate in advanced development engineering concerned with the solution of complex systems engineering and equipment problems; to undertake the design of specific hardware which may involve the first practical utilization of new knowledge.

AT ALL LEVELS, the opportunities for professional growth are exceptional, not only through concentration on work in advanced areas but through continual contact with able men trained in other disciplines. Informal consultation between engineers, physicists, mathematicians, psychologists and linguists is available on a day to day basis. Further, with scientists it is the aim of Stromberg-Carlson's technically-trained management to maintain the atmosphere of the academic world, encouraging discussion, publication of papers and participation in technical symposia.

The list below indicates the range of work currently in progress.

FIELDS OF RESEARCH ENDEAVOR

Paramagnetic Resonance
Thin Photoconductor Films
Ferroelectricity
Propagation and Coding
Speech Analysis
Bandwidth Compression
Hydro-Acoustic Transducers
Molecular Electronics
Defect Solid State Physics
Parametric Devices
Tunnel Diode Logic
Scatter Propagation Analysis
Plasma Physics

ADVANCED DEVELOPMENT & ENGINEERING

ICBM Communications
Electronic Switching
Nuclear Instrumentation
High-Speed Digital Data Communications
Electronics Reconnaissance Systems
Single Sideband Communications
Synchronous Data Transmission
ASW Techniques
Machine Tool Automation
Radio Data Links
High Intensity Sound Generators
Air Acoustics
Shaped Beam Display Systems
High-Speed Automatic Missile Check-Out Equipment
Super-Speed Read-Out and Printing Equipment
Electro Acoustics & Transducers
Logic Systems
Sound Systems
RF Equipment
Precision Hi-Fi Components

For further information write to the College Relations Section, Engineering Personnel Department.

STROMBERG-CARLSON
A DIVISION OF **GENERAL DYNAMICS**
1450 North Goodman St., Rochester 3, New York

When writing to advertisers please mention the CORNELL ENGINEER.

LAVA

Manufacturers of Super-Refractories Only

REFRACTORY CRUCIBLES
GRAPHITE CRUCIBLES
HIGH-TEMPERATURE CEMENTS
SPECIAL REFRACTORY BRICK, TILE, SHAPES

From the Following Materials:—

GRAPHITE — SILICON CARBIDE — FUSED ALUMINA — MULLITE
MAGNESIA ZIRCON

also

CUSTOM PRODUCERS OF ELECTRICALLY FUSED REFRACTORY GRAINS

LAVA CRUCIBLE-REFRACTORIES CO.
PITTSBURGH, PA.

ON WEATHERING WINTER . . .

The Annual invasion of Old Man Winter is imminent and our Men's Wear Dept. suggests you be prepared with a warm coat.

Poplin Shell-Blanket or Fleece Lining	$29.95
Wool Tweed-Quilted Lining	$22.95 and $29.95
Wool Loden-Blanket Lining	$32.50
Corduroy-Fleece Lining	$29.95
Blanket Lining	$29.95
Wool Check-Alpaca Lining	$39.95

The Cornell Campus Store
Barnes Hall

Printing
Promotes
Progress

•

The Cayuga Press
113 E. Green St. Ithaca, N. Y.
Phone 2-2781

When writing to advertisers please mention the CORNELL ENGINEER.

THE CORNELL ENGINEERING STUDENT COUNCIL

by Arnold Jacobs, ME '61
Council President

The purpose of the Cornell Engineering Student Council is to promote and coordinate student activities in the College of Engineering, and to provide a liaison between the undergraduates and the administration and the faculty. Since the Engineering Council, as it is commonly called, only infrequently seeks publicity, its work is not as well known as that of some other groups on campus.

The Council is made up of twenty-three members, who are representatives of the third, fourth, and fifth year classes in each of the seven schools of the College—Agricultural Engineering, Chemical Engineering, Civil Engineering, Electrical Engineering, Engineering Physics, Mechanical Engineering, and Metallurgical Engineering. In addition, the president of Tau Beta Pi and the Editor-in-Chief of the "Cornell Engineer" are ex-officio members. The representatives are elected for three year terms by popular vote of the students in their respective schools. The officers, in turn, are elected by members of Council.

The Engineering Council was founded in 1948. At that time, its sole purpose was the promotion of Engineers' Day, but a few years later the members of Council began, during vacations, to contact prospective freshmen. Since that time Day Hall has realized the value of this idea, and the 400-man Undergraduate Secondary Schools Committee has been formed to take over the job that was originally handled by the members of Engineering Council.

In 1958, the Student-Faculty Committee on College Affairs was formed. The membership of this committee is comprised of a faculty representative from each school in the College, Engineering Council, and Dean John F. McManus (Assistant Dean of the College of Engineering and advisor to Engineering Council.) It is this group that has been instrumental in promoting the free exchange of ideas and opinions among the three segments of the College: the students, the faculty, and the administration. In the past this committee has discussed such topics as the adviser system and the problem of choosing liberal electives. As a result of these meetings, a re-evaluation of both the adviser system and the curriculum is now in progress.

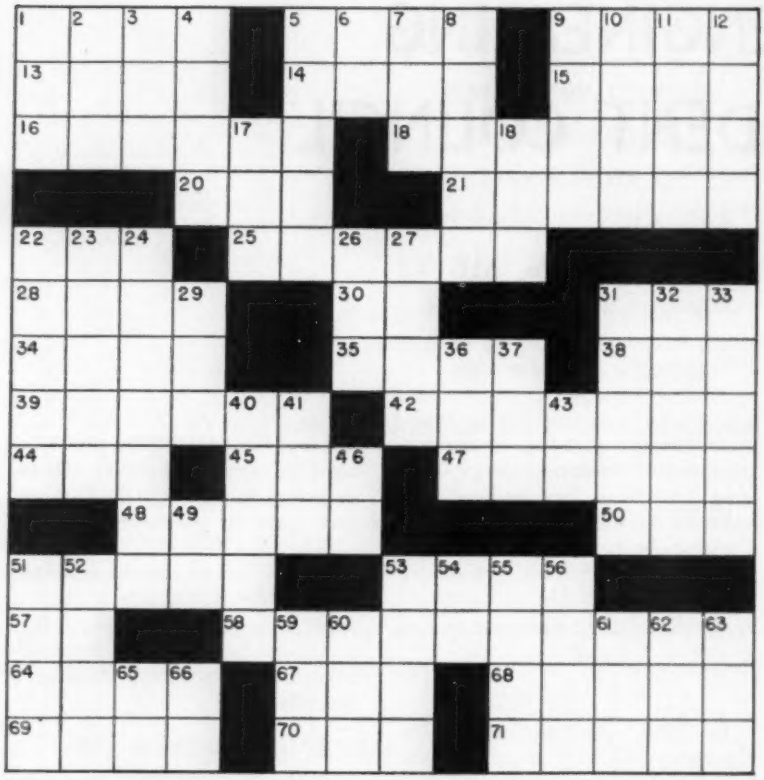
Engineers' Day, which was mentioned earlier, is held every Spring for the large number of high school students who visit Cornell. The 300 of this group who are interested in engineering are shown what Cornell and the engineering profession have to offer them. Over 100 engineering students (in the College) take part in preparing displays, which the sub-frosh are shown in a country fair or round-robin fashion. A large percentage of the students who attend Engineers' Day, a survey has shown, eventually become freshmen in the College of Engineering.

Although organizing Engineers' Day and participating in the Student-Faculty Committee on College Affairs are its two main functions, Engineering Council engages in other activities. Council plans to mail letters to incoming freshmen, welcoming them to Cornell and explaining some of the activities open to them as students in the College. Also, Council hopes to coordinate the efforts of the various honoraries in distributing questionnaires which would allow students to anonymously evaluate the courses that they had taken each term. The questionnaire would, in turn, be given to the faculty member who teaches the respective course.

This year Council will be more active than it has ever been. It will continue working mostly behind the scenes, to attempt to make the College an even better place for its student body.

STRESS *and* STRAIN . . .

Edited by D. J. Martin, ME '62



DEFINITIONS

ACROSS

1 Healthy
5 Newspaper section (abbr.)
9 Fruit drinks
13 German river
14 Roman emperor and fiddler
15 Grade
16 Two_____determine a straight line
18 Shoulder decoration
20 Female sheep
21 Entangle
22 Unit of current
25 Ermine's relatives
28 Greater amount
30 Exist
31 Theatre sign
34 Holly
35 African river
38 Where chemistry students toil
39 Father of chemical atomic theory
42 Winged ant
44 Yale
45 Home of captive wild animals
47 Inclines
48 Anchors
50 Elevation (abbr.)
51 City in Germany
53 Aid
57 Sun God
58 In all places
64 Snatch
67 Macaw
68 Artist's stand
69 Location
70 _____ hunter
71 Printer's marks

DOWN

1 Jump
2 Bustle
3 Hawaiian wreath
4 Sea eagle
5 Attack
6 Exist
7 Anger
8 Drunkard
9 Lily-plant
10 Valley
11 Summers (fr.)
12 Son of Adam
17 Log^{10} 100
18 Reply (abbr.)
22 Compound of ammonia
23 Moles per 1000 grams solvent
24 Bone of all Cornellians
26 Light brown
27 Send forth
29 Extension (abbr.)
31 _____ rule
32 Badger-like mammal
33 Corpulent
36 Shake a _____!
37 Make a mistake
40 O_3
41 Neither
43 _____ kettle
46 Bone
49 Faroes Island whirlwind
51 Dyne-centimeters
52 Hindu garment
53 United _____ Republic
54 Near
55 Plural of 20 across
56 This or _____
59 Huge vessel
60 Age
61 Direction
62 To soak
63 Elevated trains (colloq)
65 Preposition
66 Symbol for beryllium

Solution will appear next month

A lady busily engaged in washing her upstairs windows leaned out too far and fell, landing squarely in a garbage can. A passing Chinese gentleman looked, shrugged, and said, "Americans, velly wasteful. Woman good for ten years yet."

• • •

"Was your friend shocked over the death of his mother-in-law?"

"Shocked? He was electrocuted."

• • •

While visiting America, a lovely French maiden discovered both her visa and her money had vanished. She was in great despair until an enterprising young sailor came to her rescue.

"My ship is sailing tonite," he said. "I'll smuggle you aboard, hide you in the hold and provide you with food and blankets. All it will cost you is a little affection."

She consented and he carried out his promise, visiting her several times daily. This went on for several weeks until one day the captain of the ship discovered the sailor paying her a visit. After the sailor had gone, he confronted the girl and upon hearing her sad story mused, "I admire the young seaman's ingenuity. However, I feel it's only fair that I inform you this is the Staten Island Ferry."

Editor's Note:

If you enjoyed these jokes, you will be able to read them again in next month's CORNELL WIDOW.

Ramathan Toole

If your sights are set on research and development–

Jet heat blast of more than 15,000 degrees Fahrenheit flares over surface of an experimental nose cone shape in a physics laboratory of Avco Research and Advanced Development Division, Wilmington, Mass.

–you'll find **Photography at Work** with you

RESEARCH and development engineers find photography one of their most versatile tools. Camera and film can record the readings of instruments—can capture for study the fleeting transient on the oscilloscope face. The content and structure of metals can be studied by photospectrography or x-ray diffraction. And stresses in parts are visualized by photographing plastic models with transmitted polarized light.

There's hardly a field on which you can set your sights where photography does not play a part in simplifying work and routine. It saves time and costs in research, on the production line, in the engineering and sales departments, in the office.

So in whatever you plan to do, take full advantage of all the ways photography can help.

CAREERS WITH KODAK:

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design, sales, and production.

If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, N. Y.

EASTMAN KODAK COMPANY
Rochester 4, N. Y.

Kodak
TRADE MARK

One of a series*

Interview with General Electric's Charles F. Savage Consultant—Engineering Professional Relations

How Professional Societies Help Develop Young Engineers

UNIVERSITY MICROFILMS
313 N. FIRST ST.
ANN ARBOR, MICH

Q. Mr. Savage, should young engineers join professional engineering societies?

A. By all means. Once engineers have graduated from college they are immediately "on the outside looking in," so to speak, of a new social circle to which they must earn their right to belong. Joining a professional or technical society represents a good entree.

Q. How do these societies help young engineers?

A. The members of these societies —mature, knowledgeable men— have an obligation to instruct those who follow after them. Engineers and scientists—as professional people—are custodians of a specialized body or fund of knowledge to which they have three definite responsibilities. The first is to *generate* new knowledge and add to this total fund. The second is to *utilize* this fund of knowledge in service to society. The third is to *teach* this knowledge to others, including young engineers.

Q. Specifically, what benefits accrue from belonging to these groups?

A. There are many. For the young engineer, affiliation serves the practical purpose of exposing his work to appraisal by other scientists and engineers. Most important, however, technical societies enable young engineers to learn of work crucial to their own. These organizations are a prime source of ideas — meeting colleagues and talking with them, reading reports, attending meetings and lectures. And, for the young engineer, recognition of his accomplishments by associates and organizations generally heads the list of his aspirations. He derives satisfaction from knowing that he has been identified in his field.

Q. What contribution is the young engineer expected to make as an active member of technical and professional societies?

A. First of all, he should become active in helping promote the objectives of a society by preparing and presenting timely, well-conceived technical papers. He should also become active in organizational administration. This is self-development at work, for such efforts can enhance the personal stature and reputation of the individual. And, I might add that professional development is a continuous process, starting prior to entering college and progressing beyond retirement. Professional aspirations may change but learning covers a person's entire life span. And, of course, there are dues to be paid. The amount is graduated in terms of professional stature gained and should always be considered as a personal investment in his future.

Q. How do you go about joining professional groups?

A. While still in school, join student chapters of societies right on campus. Once an engineer is out working in industry, he should contact local chapters of technical and professional societies, or find out about them from fellow engineers.

Q. Does General Electric encourage participation in technical and professional societies?

A. It certainly does. General Electric progress is built upon creative ideas and innovations. The Company goes to great lengths to establish a climate and incentive to yield these results. One way to get ideas is to encourage employees to join professional societies. Why? Because General Electric shares in recognition accorded any of its individual employees, as well as the common pool of knowledge that these engineers build up. It can't help but profit by encouraging such association, which sparks and stimulates contributions.

Right now, sizeable numbers of General Electric employees, at all levels in the Company, belong to engineering societies, hold responsible offices, serve on working committees and handle important assignments. Many are recognized for their outstanding contributions by honor and medal awards.

These general observations emphasize that General Electric does encourage participation. In indication of the importance of this view, the Company usually defrays a portion of the expense accrued by the men involved in supporting the activities of these various organizations. Remember, our goal is to see every man advance to the full limit of his capabilities. Encouraging him to join Professional Societies is one way to help him do so.

Mr. Savage has copies of the booklet "Your First 5 Years" published by the Engineers' Council for Professional Development which you may have for the asking. Simply write to Mr. C. F. Savage, Section 959-12, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: Salary • Why Companies have Training Programs • How to Get the Job You Want.**

GENERAL ELECTRIC